IBM LTO Tape Drives

Contents

Overview

Introduction to the IBM® LTO tape drives and product description.

Each generation LTO tape drive is a high-performance, high-capacity data-storage device that is designed to back up and restore open systems applications.

An LTO tape drive can be purchased for use as stand-alone drive (TS22xx) or as part of an IBM library (TS2900, TS4300, TS4500).

Table 1. LTO generations

MTM	Description	Offerings
3580-TD9	LTO 9 Full-Height	TS4300, TS4500
3580-HH9	LTO 9 Half-Height	TS2290, TS2900, TS4300
3580-TD8	LTO 8 Full-Height	TS4300, TS4500
3580-HH8	LTO 8 Half-Height	TS2280, TS2900, TS4300
3580-TD7	LTO 7 Full-Height	TS4300, TS4500
3580-HH7	LTO 7 Half-Height	TS2270, TS2900, TS4300

For older generations of the IBM 3580 (TS2260/TS2360 and earlier), refer to the IBM Publications website to find the appropriate Setup. Operator, and Service Guides online.

- Select **United States** for the country/region/language to begin (for English), then click **>**.
- Click **SEARCH FOR PUBLICATIONS**.
- In the **Search on** box, type the generation of TS22xx tape drive (such as TS2260), then click **Start search**.

Drive information

LTO tape drives are offered in both full height and half height form factor.

Full-height drives

Table 2. Drive information and performance specification

Generation	LTO 9	LTO 8	LTO 7	LTO 6	LTO 5
Inquiry	ULT3580-TD9 ULTRIUM-TD9	ULT3580-TD8 ULTRIUM-TD8	ULT3580-TD7 ULTRIUM-TD7	ULT3580-TD6 ULTRIUM-TD6	ULT3580-TD5 ULTRIUM-TD5
Interface (speed)	FC (8 Gb) SAS (12 Gb)	FC (8 Gb)	FC (8 Gb)	FC (8 Gb)	FC (8 Gb)
Native data rate	400 Mb/s (L9) 360 Mb/s (L8)	360 Mb/s (L8) 300 Mb/s (M8) 300 Mb/s (L7)	300 Mb/s (L7) 160 Mb/s (L6) 140 Mb/s (L5)	160 Mb/s (L6) 140 Mb/s (L5) 120 Mb/s (L4)	140 Mb/s (L5) 120 Mb/s (L4) 80 Mb/s (L3)

Table 2. Drive information and performance specification (continued)					
Generation	**LTO 9**	**LTO 8**	**LTO 7**	**LTO 6**	**LTO 5**
Sustained data rate (L6, L7, L8 and L9 compressed at 2.5:1 compression; L5 and earlier compressed at 2:1 compression)	FC 750 Mb/s (L9) 750 Mb/s (L8) SAS 1000 Mb/s (L9) 900 Mb/s (L8)	FC 750 Mb/s (L8) 750 Mb/s (M8) 750 Mb/s (L7)	FC 750 Mb/s (L7) 400 Mb/s (L6) 280 Mb/s (L5)	FC and SAS 400 Mb/s (L6) 280 Mb/s (L5) 240 Mb/s (L4)	FC and SAS 280 Mb/s (L5) 240 Mb/s (L4) 160 Mb/s (L3)
Burst data rate	800 Mb/s FC 1200 Mb/s SAS	800 Mb/s FC	800 Mb/s FC	800 Mb/s FC 600 Mb/s SAS	800 Mb/s FC 600 Mb/s SAS
Nominal load-to-ready time	17 seconds	15 seconds	15 seconds	12 seconds	12 seconds
-Initialized tape	17 seconds	NA	NA	NA	NA
-Uninitialized tape[2]	40-120 minutes	NA	NA	NA	NA
Nominal unload time	30 seconds	24 seconds	20 seconds	17 seconds	17 seconds
Average space record time from load point	45 seconds	59 seconds	56 seconds	62 seconds	60 seconds
Average rewind time (REWIND command)	55 seconds	59 seconds	60 seconds	NA	NA
Average rewind time (part of UNLOAD command, dependent on mount activity)[3]					
Less than 5 Gb of contiguous data transferred	55 seconds	59 seconds	60 seconds	NA	NA
5 Gb to 50 Gb of contiguous data transferred	110 seconds	59 seconds	60 seconds	NA	NA
All other types of mount activity	165 seconds	59 seconds	60 seconds	NA	NA

Table 2. Drive information and performance specification (continued)

Generation	LTO 9	LTO 8	LTO 7	LTO 6	LTO 5

[1] By using the built-in data-compression capability of the tape drive, greater data rates than the native data transfer rate are achieved. However, the actual throughput is a function of many components, such as the host system processor, disk data rate, block size, data compression ratio, SAS bus capabilities, and system or application software.

[2] Cartridge initialization time can vary. See "Media optimization" on page 4 for more information.

[3] See "Archive mode unthread" on page 5 for more information.

Remember:

- All sustained data rates depend on the capabilities of the interconnect.
- Drive performance varies with media generation and drive interface (SAS/FC).

Half-height drives

Table 3. Drive information and performance specification

Generation	LTO 9	LTO 8	LTO 7	LTO 6	LTO 5
Inquiry	ULT3580-HH9 ULTRIUM-HH9	ULT3580-HH8 ULTRIUM-HH8	ULT3580-HH7 ULTRIUM-HH7	ULT3580-HH6 ULTRIUM-HH6	ULT3580-HH5 ULTRIUM-HH5
Interface (speed)	FC (8 Gb) SAS (12 Gb)	FC (8 Gb) SAS (6 Gb)	FC (8 Gb) SAS (6 Gb)	FC (8 Gb) SAS (6 Gb)	FC (8 Gb) SAS (6 Gb)
Native data rate	300 Mb/s (L9) 300 Mb/s (L8)	300 Mb/s (L8) 300 Mb/s (M8) 300 Mb/s (L7)	300 Mb/s (L7) 160 Mb/s (L6) 140 Mb/s (L5)	160 Mb/s (L6) 140 Mb/s (L5) 120 Mb/s (L4)	140 Mb/s (L5) 120 Mb/s (L4) 80 Mb/s (L3)
Sustained data rate (L6, L7, L8 and L9 compressed at 2.5:1 compression; L5 and earlier compressed at 2:1compression)	FC 700 Mb/s (L9) 700 Mb/s (L8) SAS 720 Mb/s (L9) 720 Mb/s (L8)	FC 700 Mb/s (L8) 700 Mb/s (M8) 700 Mb/s (L7) SAS 600 Mb/s (L8) 540 Mb/s (M8) 500 Mb/s (L7)	FC 700 Mb/s (L7) 400 Mb/s (L6) 280 Mb/s (L5) SAS 500 Mb/s (L7) 400 Mb/s (L6) 280 Mb/s (L5)	FC and SAS 400 Mb/s (L6) 280 Mb/s (L5) 240 Mb/s (L4)	FC and SAS 280 Mb/s (L5) 240 Mb/s (L4) 160 Mb/s (L3)
Burst data rate	800 Mb/s FC 1200 Mb/s SAS	800 Mb/s FC 600 Mb/s SAS	800 Mb/s FC 600 Mb/s SAS	800 Mb/s FC 600 Mb/s SAS	800 Mb/s FC 600 Mb/s SAS
Nominal load-to-ready time	16 seconds	15 seconds	15 seconds	12 seconds	12 seconds
-Initialized tape	16 seconds	NA	NA	NA	NA
-Uninitialized tape[2]	40-132 minutes	NA	NA	NA	NA
Nominal unload time	56 seconds	24 seconds	20 seconds	17 seconds	17 seconds

Table 3. Drive information and performance specification (continued)					
Generation	**LTO 9**	**LTO 8**	**LTO 7**	**LTO 6**	**LTO 5**
Average space record time from load point	65 seconds	59 seconds	56 seconds	62 seconds	60 seconds
Average rewind time (REWIND command)	62 seconds	59 seconds	60 seconds	NA	NA
Average rewind time (part of UNLOAD command, dependent on mount activity)[3]					
Less than 5 Gb of contiguous data transferred	62 seconds	59 seconds	60 seconds	NA	NA
5 Gb to 50 Gb of contiguous data transferred	124 seconds	59 seconds	60 seconds	NA	NA
All other types of mount activity	186 seconds	59 seconds	60 seconds	NA	NA

[1] By using the built-in data-compression capability of the tape drive, greater data rates than the native data transfer rate are achieved. However, the actual throughput is a function of many components, such as the host system processor, disk data rate, block size, data compression ratio, SAS bus capabilities, and system or application software.

[2] Cartridge initialization time can vary. See "Media optimization" on page 4 for more information.

[3] See "Archive mode unthread" on page 5 for more information.

Remember:

- All sustained data rates depend on the capabilities of the interconnect.
- Drive performance varies with media generation and drive interface (SAS/FC).

Drive features

Media optimization

Media optimization is a new feature for the LTO9 tape drive with L9/LZ media.

The increased number of tracks used to write data on tape requires greater precision. Media optimization creates a referenced calibration for each cartridge that enables the tape drive's intelligent alignment to optimize data placement. LTO-9 media optimization enhances LTO tape long-term media durability.

It is important to consider when media optimization will be performed:

- Media optimization will be performed on first load of L9/LZ media during initialization.
- Recommendation is to perform first load in the location of deployment, which should be in a stable environment that meets the recommended environmental specification (see Environment specifications for details).
- Media optimization is a one-time operation that can be completed on any drive in the environment, enabling the media to be used across all tape drives without further optimization.

Other considerations for media optimization:

- Media optimization averages 40 minutes per first load of a cartridge to a tape drive. Although most media optimizations will complete within 60 minutes some media optimizations may take up to 2 hours.
- Interruption of the process is not recommended.
- A different mount will not necessarily improve the time to complete the one-time optimization.

An update to software may be required. Contact your software application provider for more details. Customized software, not provided as a standard market product, may require modification to ensure the software can handle the extended first mount time. For additional details, review the detailed section of the IBM LTO SCSI Reference.

Recommended access order (RAO) open function

RAO enables tape control applications to accelerate the retrieval of a certain number of files from a single tape thereby reducing the seek time between those files.

A feature of the LTO-9 full-height drives is the ability to accept a list of User Data Segments and reorder those User Data Segments into a recommended access order that minimizes the locate portion of the time to read those User Data Segments. This sorted list is called a Recommended Access Order (RAO) list. A User Data Segment (UDS) is defined as a grouping of contiguous logical objects (i.e., logical blocks and filemarks) and is described by partition number, beginning logical object identifier, and ending logical object identifier.

The RAO implementation in LTO produces the best results for performance enhancement when there is little variability in block size or data compression ratio. When the variability in compression ratio or block sizes increase, the accuracy of the locate estimates may be reduced and any potential performance enhancements may be diminished.

Archive mode unthread

The drive archive mode unthread feature is designed to fine-tune the media for long term storage by ensuring that the media inside the cartridge is stored at an optimal tension.

Tuning to optimal tension requires longer unthread time. The time that is required for an unload depends on how the cartridge has been used during the mount. This is based on the current position and how far from the beginning of tape (BOT) the media has been moved since mount. For details on unload performance, see “Drive information” on page 1.

This feature is available with LTO-7 and later tape drives. For more details, see SCSI Reference.

Speed matching

To improve system performance, the drive uses a technique that is called *speed matching* to dynamically adjust its native (uncompressed) data rate to the slower data rate of a server.

With speed matching, the drive operates at different speeds when it is reading or writing the Ultrium 7 or later cartridge format. Native data rates are shown in the table.

Table 4. Performance parameters for full height drives			
	Ultrium Generation Media		
	Generation 9 media	**Generation 8 media**	**Generation 7 media**
Speed matching data rates (MB/sec)	408	365.0	306.0
	385	341.0	287.52
	366	318.0	268.56
	347	306.4	250.66
	325	273.0	231.86
	305	249.5	213.06
	284	226.0	194.26
	263	203.0	175.46
	244	180.0	157.67
	223	157.5	138.52
	203	135.0	120.11
	177	112.0	101.46

Table 5. Performance parameters for half height drives			
	Ultrium Generation Media		
	Generation 9 media	**Generation 8 media**	**Generation 7 media**
Speed matching data rates (MB/sec)	284	306.4	306.0
	263	273.0	287.52
	244	249.5	268.56
	223	226.0	250.66
	203	203.0	231.86
	177	180.0	213.06
	-	157.5	194.26
	-	135.0	175.46
	-	112.0	157.67
	-	-	138.52
	-	-	120.11
	-	-	101.46

If the server's net (compressed) data rate is between two of the preceding native data rates, the drive calculates the appropriate data rate at which to operate. Speed matching dramatically reduces backhitch, the condition that occurs when a tape stops, reverses, and restarts motion. A backhitch is usually the result of a mismatch between the data rates of the server and the drive.

Channel calibration

System performance is optimized by *channel calibration*.

System performance is further optimized by a feature that is called *channel calibration*, in which the drive automatically customizes each read/write data channel to compensate for variations in such things as the recording channel 's transfer function, the media, and characteristics of the drive head.

Data cartridge capacity scaling

Capacity scaling enables faster random access to data.

The **SET CAPACITY SCSI** command enables a customer to capacity scale a data cartridge to enable faster random access. As an example, a customer can capacity scale a data cartridge to 20% of its normal length that improves the average access time by almost a factor of 5. However, it also reduces the native capacity of the tape to 1.2 TB.

Encryption

The LTO tape drive supports host Application Managed Encryption (AME), with T10 encryption methods.

Data encryption is supported by LTO Ultrium 4 and later data cartridges only.

The encryption-enabled drive contains the necessary hardware and firmware to encrypt and decrypt host tape application data. Encryption policy and encryption keys are provided by the host application. A drive digital certificate is installed at manufacturing time. Each drive receives a unique serial number and certificate. The T10 Application can validate each drive instance by checking the drive's digital certificate.

For details, see the *IBM Tape Device Drivers Encryption Support* documentation, and the *IBM LTO Ultrium Tape Drive SCSI Reference* documentation.

Front right panel of the drive

The front panels of the half-height drives - element descriptions.

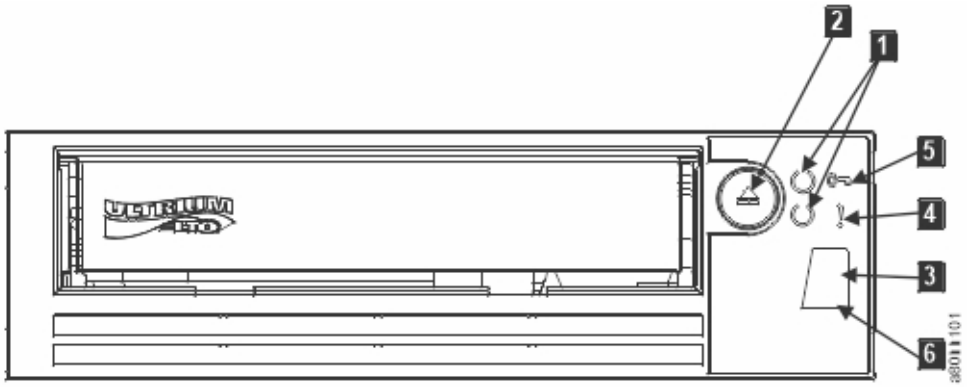

Figure 1. Half-height front right panel element descriptions

1	Two status LED indicators (green)	4	Fault light (amber)
2	Unload button	5	Encryption light (white)
3	Single-character display	6	SCD dot

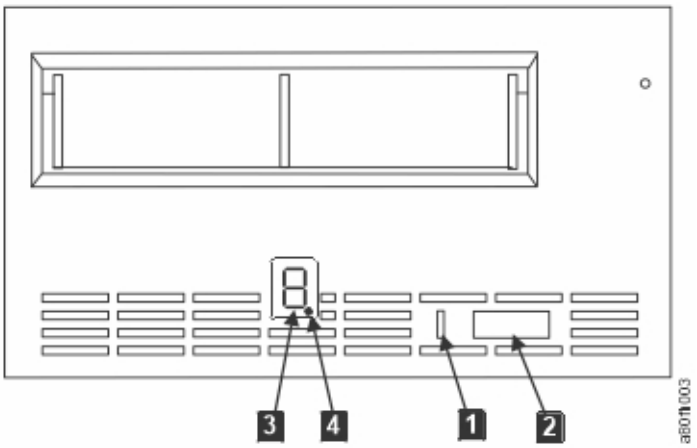

Figure 2. Full-height bottom front panel element descriptions

1	LED indicator
2	Unload button
3	Single-character display
4	SCD dot

Media compatibility

IBM Ultrium media is available in the following types:

- Data cartridge
- WORM (Write Once, Read Many) cartridge
- Cleaning cartridge

All generations contain 1/2-inch, dual-coat, magnetic tape.

Table 6. Media drive compatibility

Tape Cartridge	LTO 9 Drive	LTO 8 Drive	LTO 7 Drive	LTO 6 Drive	LTO 5 Drive	LTO 4 Drive	LTO 3 Drive	LTO 2 Drive	LTO 1 Drive
Ultrium 9	Read/ write								
Ultrium 8	Read/ write	Read/ write							
Ultrium M8		Read/ write							
Ultrium 7		Read/ write	Read/ write						
Ultrium 6			Read/ write	Read/ write					
Ultrium 5			Read only	Read/ write	Read/ write				
Ultrium 4				Read only	Read/ write	Read/ write			

Table 6. Media drive compatibility (continued)									
Ultrium 3					Read only	Read/ write	Read/ write		
Ultrium 2						Read only	Read/ write	Read/ write	
Ultrium 1							Read only	Read/ write	Read/ write

Table 7. Media Information

LTO Generation	Native Data Capacity	Application Design Capacity	Bar code Label[1]	Load/Unload Cycles	Recording Format[2]	Color
Ultrium 9	18 TB (45 TB at 2.5:1 compression)	17.4 TB	xxxxxxL9 **WORM:** xxxxxxLZ	20,000	Reads and writes data on 8960 tracks, 32 tracks at a time.	Teal **WORM:** Teal and Silvery gray
Ultrium 8	12 TB (30 TB at 2.5:1 compression)	11.6 TB	xxxxxxL8 **WORM:** xxxxxxLY	20,000	Reads and writes data on 6656 tracks, 32 tracks at a time.	Burgundy **WORM:** Burgundy and Silvery gray
Ultrium M8[3]	9 TB (22.5 TB at 2.5:1 compression)	8.37 TB	xxxxxxM8	20,000	Reads and writes data on 3584 tracks, 32 tracks at a time.	Purple
Ultrium 7	6 TB (15 TB at 2.5:1 compression)	NA	xxxxxxL7 **WORM:** xxxxxxLX	20,000	Reads and writes data on 3584 tracks, 32 tracks at a time.	Purple **WORM:** Purple and Silvery gray
Ultrium 6	2.5 TB (6.25 TB at 2.5:1 compression)	NA	xxxxxxL6 **WORM:** xxxxxxLW	20,000	Reads and writes data on 2176 tracks, 16 tracks at a time.	Black **WORM:** Black and Silvery gray
Ultrium 5	1.5 TB (3 TB at 2:1 compression)	NA	xxxxxxL5 **WORM:** xxxxxxLV	20,000	Reads and writes data on 1280 tracks, 16 tracks at a time.	Burgundy **WORM:** with Slate Gray

Table 7. Media Information (continued)

LTO Generation	Native Data Capacity	Application Design Capacity	Bar code Label[1]	Load/Unload Cycles	Recording Format[2]	Color
Ultrium 4	800 GB (1.6 TB at 2:1 compression)	NA	xxxxxxL4 **WORM:** xxxxxxLU	20,000	Reads and writes data on 896 tracks, 16 tracks at a time.	Green **WORM:**Green and Silvery gray
Ultrium 3	400 GB (800 GB at 2:1 compression)	NA	xxxxxxL3 **WORM:** xxxxxxLT	10,000	Reads and writes data on 704 tracks, 16 tracks at a time.	Slate Blue **WORM:**Slate Blue and Silvery gray
Ultrium 2	200 GB (400 GB at 2:1 compression)	NA	xxxxxxL2	10,000	Reads and writes data on 512 tracks, 8 tracks at a time.	Purple
Ultrium 1	100 GB (200 GB at 2:1 compression)	NA	xxxxxxL1	5000	Reads and writes data on 384 tracks, 8 tracks at a time.	Black

[1]You can order tape cartridges with the bar code labels included, or you can order custom labels. To obtain tape cartridges and bar code labels, see "Ordering media supplies" on page 73.

[2]When tape is processed in the cartridges, Ultrium tape drives use a linear, serpentine recording format.

[3]"LTO type M cartridge (M8)" on page 58

Tip: For additional information, see "LTO media" on page 55 section.

Planning

The LTO tape drive requires an environment able to accommodate the appropriate space, power, location, and other technical specifications. Use this section as a reference for onsite requirements to allow for optimum operation of the drive.

Acclimation

Tape storage equipment must be gradually acclimated to the surrounding environment to prevent condensation.

When storage equipment is shipped in a climate where the outside temperature is below the dew point of the destination (indoor location), water condensation can form on the cooler inside and outside surfaces of the equipment when the equipment is brought indoors.

Sufficient time must be allowed for the shipped equipment to gradually reach thermal equilibrium with the indoor environment before you remove the shipping bag and energize the equipment. Follow these guidelines to properly acclimate your equipment:

- Leave the system in the shipping bag. If the installation or staging environment allows it, leave the product in the full package to minimize condensation on or within the equipment.
- Allow the packaged product to acclimate for 24 hours[1]. If visible signs of condensation (either external or internal to the product) are seen after 24 hours, acclimate the system without the shipping bag for an extra 12 - 24 hours or until no visible condensation remains.
- Acclimate the product away from perforated tiles or other direct sources of forced air convection to minimize excessive condensation on or within the equipment.

[1] Unless otherwise stated by product-specific installation instructions.

Note: Condensation is a normal occurrence, especially when you ship equipment in cold-weather climates. All IBM products are tested and verified to withstand condensation that is produced under these circumstances. When sufficient time is provided to allow the hardware to gradually acclimate to the indoor environment, no issues with long-term reliability of the product should occur.

Location requirements

Information for planning the installation and layout of your LTO tape drive, including various specifications for optimal performance.

Specifications for tape cartridges are given in "Environmental and shipping specifications for tape cartridges" on page 72.

Security

The equipment must be located so that access to the equipment can be controlled and monitored. Consider all of these recommended security measures when you're determining where to locate your tape library.

Location
You're responsible for the security of this tape drive, and the cartridges used with the tape drive. To prevent unauthorized access to data, IBM recommends locating the library and all shelf-resident cartridges in an area where access is controlled.

Onsite security measures
You're also responsible for evaluating, selecting, and implementing security features, administrative procedures, and appropriate controls in application systems and communication facilities.

Electrical specifications

Table 8. LTO tape drive power supply requirements

	FC	SAS
Power® Supply	5 V dc	12 V dc
Tolerance	10%	10%
Voltage Ripple/Noise (50 Hz - 20 MHz)	60 m pp	125 m pp
Supply Current		
Minimum (steady rate) (A)	2.0 A	0.0 A
Maximum (steady rate) (A)	4.1 A FH 4.0 A HH	TBD

Table 8. LTO tape drive power supply requirements (continued)		
	FC	**SAS**
Peak (instantaneous power)	4.5 A < 1 ms	4.0 A < 1 ms

Drive temperature and humidity specifications

Table 9. Drive temperature and humidity specifications					
Mode	**Dry-Bulb Temperature**	**Maximum Temperature Rate of Change**	**Relative Humidity (non-condensing)**	**Maximum Humidity Rate of Change**	**Altitude (max)**
Recommended environment	16°C to 25°C	5°C an hour	20% to 80% 22°C dew point max	5%/hour with no condensation	3050 m
Allowable environment	16°C to 32°C	5°C an hour	20% to 50%	5%/hour with no condensation	3048 m
Shipping	-40°C to 60°C		10% to 90% non-condensing		12192 m

Table 10. Equipment environment specification								
Equipment environment specification								
Product power off[1]								
Dry-bulb temperature			**Relative humidity**			**Maximum wet-bulb temperature**		
5 to 45°C (40 to 113°F)			8% to 80% RH			26°C (79°F)		
Product operation (equipment is powered on)								
Dry-bulb temperature			**Humidity range, non-condensing**			**Maximum dew point temperature[4]**	**Maximum wet-bulb temperature[4]**	**Maximum elevation**
Allowable[2]	**Recommended[3]**	**Maximum rate of change**	**Allowable**	**Recommended**	**Maximum rate of change**	22°C (72°F) for LTO 9	26°C (79°F)	3050 m (10,000 feet)
15 to 35°C (59 to 95°F)	15 to 25°C (59 to 77°F)	5°C/ hour (9°F/ hour)	20% to 80% RH	20% to 50% RH	5% RH/ hour with no condensation			

Table 10. Equipment environment specification (continued)
Equipment environment specification
Note: 1. Product equipment is removed from the original shipping container and installed but not in use - for example, during repair, maintenance, or upgrade. 2. Derate maximum dry-bulb temperature 1°C/300 m above 900 m (1.8°F/1,000 feet above 3,000 feet). 3. Derate maximum recommended dry-bulb temperature 1°C/300 m above 1,800 m (1.8°F/1,000 feet above 6,000 feet). 4. Applies to LTO 9 drives 5. Applies to LTO drive generations 1 through 8.

Psychrometric chart

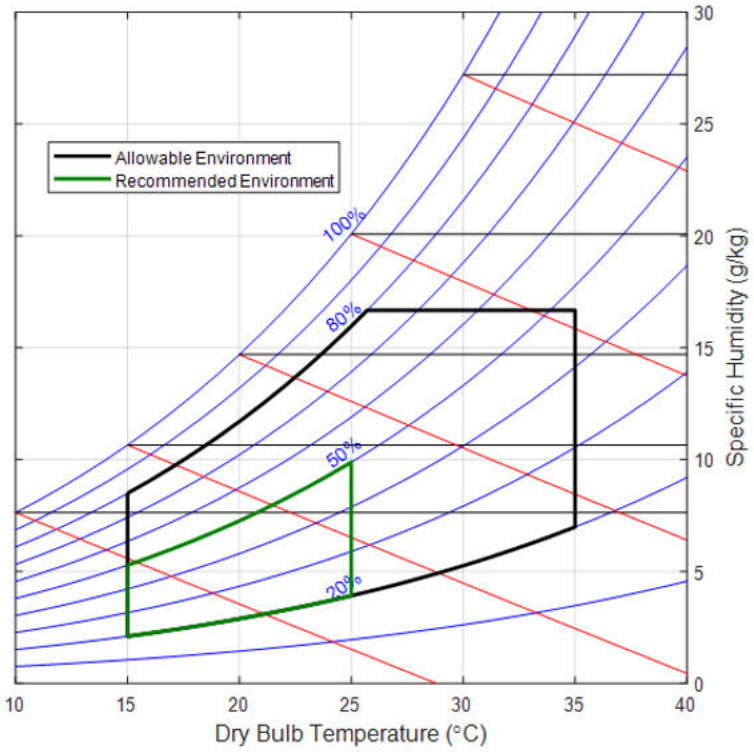

Figure 3. Psychrometric chart showing recommended and allowable operating environments for the tape drive

Notes:

- The chart is shown in SI (metric) units and a barometric pressure of 101.325 kPa (sea level).
- The recommended operating environment specifies a long-term operating environment that can result in the greatest reliability and energy efficiency.
- The allowable operating environment represents where the equipment was tested to verify functions. Due to the stresses that operating in the allowable envelope can place on the equipment, these envelopes should be used for short-term operation, not continuous operation (for example, in the case of a cooling failure).

Gas and particulate exposure

Table 11. Gas and particulate exposure

Contamination	Requirement
Gaseous contamination	Severity level G1 as per ANSI/ISA 71.04-1985[1], which states that the reactivity rate of copper coupons shall be fewer than 300 Angstroms per month (Å/month, ≈ 0.0039 µg/cm² - hour weight gain)[2]. In addition, the reactivity rate of silver coupons shall be less than 300 Å/month (≈ 0.0035 µg/cm² - hour weight gain)[3]. The reactive monitoring of gaseous corrosivity should be conducted approximately 5 cm (2 in.) in front of the rack on the air inlet side at one-quarter and three-quarter frame height off the floor or where the air velocity is much higher.
Particulate contamination	Data centers must meet the cleanliness level of ISO 14644-1 class 8. For data centers without airside economizer, the ISO 14644-1 class 8 cleanliness might be met by the choice of the following filtration: • The room air might be continuously filtered with MERV 8 filters. • Air entering a data center might be filtered with MERV 11 or preferably MERV 13 filters. For data centers with airside economizers, the choice of filters to achieve ISO class 8 cleanliness depends on the specific conditions present at that data center. The deliquescent relative humidity of the particulate contamination should be more than 60% RH.3[4].Data centers must be free of zinc whiskers[5].

Notes:

1. ANSI/ISA-S71.04. 1985. *Environmental conditions for process measurement and control systems: Airborne contaminants*, Instrument Society of America, Research Triangle Park, NC, 1985.
2. The derivation of the equivalence between the rate of copper corrosion product thickness growth in Å/month and the rate of weight gain assumes that Cu2S and Cu2O grow in equal proportions.
3. The derivation of the equivalence between the rate of silver corrosion product thickness growth in Å/month and the rate of weight gain assumes that Ag2S is the only corrosion product.
4. The deliquescent relative humidity of particulate contamination is the relative humidity at which the dust absorbs enough water to become wet and promote ionic conduction.
5. Surface debris is randomly collected from 10 areas of the data center on a 1.5-cm diameter disk of sticky electrically conductive tape on a metal stub. If examination of the sticky tape in a scanning electron microscope reveals no zinc whiskers, the data center is considered free of zinc whiskers.

Host requirements

The drive is supported by a wide variety of servers, operating systems, and adapters. Many ways to determine the servers and software that supports this drive are available.

SAS interface

The SAS interface speed varies with the generation of the LTO drive. For more information on SAS speed of different generation drives, see “Drive information” on page 1.

A drive with a SAS interface can be linked directly to controllers. SAS is a performance improvement over traditional SCSI because SAS enables multiple devices (up to 128) of different sizes and types to be connected simultaneously with thinner and longer cables. Its full-duplex signal transmission supports up to 12.0 Gbps. In addition, SAS drives can be hot-plugged.

SAS drives auto-negotiate speed. There are no configurable topologies thus no feature switches associated with SAS.

Fibre Channel interface

The fibre channel interface varies with the generation of the drive.

Fibre Channel technology combines the best features of traditional input/output interfaces with the best features of networking interfaces. The technology offers a transport mechanism for delivering commands, and provides high performance by allowing processing to be done in the hardware.

The Fibre Channel connector is a Small Form-Factor Pluggable (SFP), dual-port, multimode optical transceiver that consists of an industry standard duplex LC-type connector.

You can establish Fibre Channel connections between Fibre Channel ports that are in the tape library, one or more servers, and the connecting network. The network can consist of such elements as switches, hubs, bridges, and repeaters.

Compatible configurations

For a comprehensive list of compatible configurations, see the IBM Interoperation Center (SSIC) at http://www-03.ibm.com/systems/support/storage/ssic/interoperability.wss.

Compatible servers and software

Note: These attachments can change throughout the lifecycle of the product.

For complete IBM storage interoperability information for the tape drive in a storage area network (SAN) configuration, see the IBM Interoperation Center (SSIC) at http://www-03.ibm.com/systems/support/storage/ssic/interoperability.wss. The SSIC has details on supported operating systems, servers, switches, and adapters.

Note:

1. IBM does not provide application software with the drive. To order software, contact your IBM sales representative, IBM Business Partner, or an independent software provider.
2. If you attach your drive to a server with non-IBM software, contact your software vendor for a matrix of compatible hardware, software, firmware revisions, and adapters.

Supported device drivers

Device drivers enable the drive to interact with various servers.

To properly install an IBM device driver (if required), refer to the IBM Tape Device Drivers Installation and User's Guide. For applications that uses other device drivers, see “Application software” on page 15 to determine which drivers to use.

IBM maintains the levels of device drivers and driver documentation for the drive on the web. You can access this material at http://www.ibm.com/support/fixcentral.

Tip: If you do not have Internet access and you need information about device drivers, contact your sales representative.

Remember: The device driver for System i servers is included in the OS/400® operating system.

Application software

Industry-leading compatible software offerings provide storage and tape management software for the LTO tape drives. Supporting software and applications must be obtained separately from IBM, IBM Business Partners, or independent software vendors (ISV). For a list of compatible software and additional information, refer to the ISV Matrix that is available at Independent Software Vendor (ISV) matrix for 3592 and LTO.

Managing

Using an updated firmware is very important to utilize the latest features of the tape drive.

Updating drive firmware

It is the customer's responsibility to ensure that this drive has the current firmware.

Check for and download the latest drive firmware level at http://www.ibm.com/support/fixcentral. Register for My Notifications at www.ibm.com/support to receive email notification when new firmware levels are available for download.

To update the firmware, use one of the methods that are described in the following sections:

Attention: When firmware is updated, do not power off the drive until the update is complete, or the firmware might be lost.

Updating firmware through the host interface

To update the drive's firmware by using a host server:

1. Open ITDT-GE.
2. To check the drive firmware level and download the latest firmware, follow instructions that are provided in Firmware update - check for updates.
3. After you download the latest firmware, see Firmware update for further instructions on updating the firmware.

Updating the firmware with an FMR tape cartridge

Attention: A SAS drive requires a SAS firmware image. Other types of firmware images do not load on the SAS drive.

To update the drive's firmware from an FMR tape cartridge:

1. Create an FMR tape (see “Function code 3: Create FMR tape” on page 21). A single FMR tape can be used to update multiple drives if the drives are the same drive type (for example, LTO 8) and host interface (for example, SAS).
2. Update the drive firmware (see “Function code 2: Update drive firmware from FMR tape” on page 20).

After the drive firmware is updated, the FMR tape can be used as a data cartridge with the help of “Function code 8: Unmake FMR tape” on page 24.

The SCD presents a series of random characters during the firmware download and update. The SCD briefly displays  , then becomes blank (not lit) when the firmware download and update is complete and there are no errors. An error code is displayed if a firmware download or update error is detected. The Ready light and the Fault light flash briefly during the firmware download and update. The Ready light turns on after the firmware download and update are complete.

Updating the firmware with the Ethernet port - Service only

Note: The drive uses a limited version of FTP protocol to communicate on the Ethernet interface. Use a simple, command-line FTP session, such as the DOS command line, to communicate with the drive.

1. Obtain the current drive firmware from the web.
2. Connect an Ethernet patch cable to the drive's Ethernet interface and to a computer. To meet electromagnetic immunity requirements, a shielded Ethernet cable is required.
3. Create an FTP session between the drive and the computer. The drive 's IP address: **169.254.0.3**
4. At the user prompt, type `guest` and press **Enter**.

5. At the password prompt, press **Enter**. No response is needed.
6. Type `bin` to set the communication mode to binary.
7. Type `put <firmware name>` to transfer the firmware to the drive. Replace `<firmware name>` with the actual firmware name. The drive resets automatically when the transfer is complete and the FTP session closes.
8. After the drive resets, the new firmware is loaded on the drive.
9. Remove the Ethernet patch cable from the drive's Ethernet interface and the computer.

Maintenance functions

Refer to this section for information on diagnosing and maintaining your tape drives.

The drive can:

- Run diagnostics
- Test write and read functions
- Test a suspect tape cartridge
- Update firmware
- Complete other diagnostic and maintenance functions

The drive must be in Maintenance mode to complete these functions.

Attention: Maintenance functions cannot be run concurrently with read or write operations. While in maintenance mode, the tape drive does not accept host interface commands from the server. The tape drive does accept LDI or RS-422 commands.

Table 12 on page 17 describes each diagnostic and maintenance function that the drive can complete, gives the function code that appears on the Single-character Display (SCD), and directs you to the instructions for completing the function. Use a customer-supplied scratch (blank) data cartridge for diagnostic testing. The diagnostic and maintenance functions are not supported on the WORM and partitioned data tape cartridges.

Table 12. Diagnostic and maintenance functions

Function Code	Diagnostic or Maintenance Function	Instructions Location
0	**Exit Maintenance Mode:** Causes the drive to become available for reading and writing data.	"Function code 0: Maintenance mode" on page 19
1	**Run Drive Diagnostics:** Runs tests to determine whether the drive can properly load and unload cartridges, and read and write data.	"Function code 1: Run drive diagnostics" on page 20
2	**Update Tape Drive Firmware from FMR Tape:** Loads updated firmware from a field microcode replacement (FMR) tape.	"Function code 2: Update drive firmware from FMR tape" on page 20
3	**Create FMR Tape:** Copies its field microcode replacement (FMR) data to a customer-supplied scratch (blank) data cartridge.	"Function code 3: Create FMR tape" on page 21
4	**Force a Drive Dump:** Completes a memory dump of data (also known as saving a microcode trace).	"Function code 4: Force a drive dump" on page 22

Table 12. Diagnostic and maintenance functions (continued)		
Function Code	**Diagnostic or Maintenance Function**	**Instructions Location**
5	**Copy Drive Dump:** Copies data from a drive memory dump (captured by using Function Code 4) to the beginning of a customer-supplied scratch (blank) data cartridge, copies a drive memory dump to flash memory, or erases a memory dump from flash memory.	"Function code 5: Copy drive dump" on page 22
6	**Run Host Interface Wrap Test:** Checks the circuitry from and to the connector.	"Function code 6: Run host interface wrap test" on page 23
7	**Run RS-422 Wrap Test:** This test causes the drive to run a check of the circuitry and connector for the RS-422 interface.	"Function code 7: Run RS-422 wrap test" on page 24
8	**Unmake FMR Tape:** Erases the FMR data on a customer-supplied scratch (blank) data cartridge and rewrite the cartridge memory on the tape. This action turns the cartridge into a valid customer-supplied scratch data cartridge.	"Function code 8: Unmake FMR tape" on page 24
9	**Display Error Code Log:** Displays the last 10 error codes, one at a time (the codes are ordered; the most recent is presented first and the oldest 10th) is presented last).	"Function code 9: Display error code log" on page 25
A	**Clear Error Code Log:** Erases the contents of the error code log.	"Function code A: Clear error code log" on page 25
C	**Insert Cartridge into Tape Drive:** This function cannot be selected by itself, but is a part of other maintenance functions (such as Run Tape Drive Diagnostics and Create FMR Tape) that require a tape cartridge to be loaded.	"Function code C: Insert cartridge into tape drive" on page 26
E	**Test Cartridge & Media:** Completes tests to ensure that a suspect cartridge and its magnetic tape are acceptable.	"Function code E: Test cartridge & media" on page 26
F	**Write Performance Test:** Completes tests to ensure that the drive can read from and write to tape.	"Function code F: Write performance test" on page 27
H	**Test Head:** Completes tests to ensure that the tape drive's head and tape-carriage mechanics are working correctly.	"Function code H: Test head" on page 27
J	**Fast Read/Write Test:** Completes tests to ensure that the drive can read from and write to tape.	"Function code J: Fast read/write test" on page 28
L	**Load/Unload Test:** Tests the drive's ability to load and unload a tape cartridge.	"Function code L: Load/unload test" on page 29
P	**Enable Post Error Reporting:** When selected, deferred-check conditions are reported to the host.	"Function code P: Post Error Reporting enabled" on page 30
U	**Disable Post Error Reporting:** When selected, deferred-check conditions are NOT reported to the host.	"Function code U: Post Error Reporting disabled" on page 30

Entering Maintenance mode

The drive must be in Maintenance mode to run drive diagnostic tests or maintenance functions.

About this task

To place the unit in Maintenance mode:

Procedure

1. Make sure that no cartridge is in the drive.
2. Press **Unload** three times within 2 seconds. 0 displays in the Single-character Display (SCD), the **Ready** light is flashing, and the **Fault** light turns On.

   Note: If a cartridge is in the tape drive, it ejects the first time that you press **Unload** and the drive is placed in Maintenance mode. To continue placing the drive in Maintenance mode, complete the preceding step. While in Maintenance mode, the drive does not accept a cartridge unless the drive requests it. The SCD displays a flashing C to indicate a cartridge must be inserted.

Results

Maintenance functions cannot be completed concurrently with read or write operations. While in Maintenance mode, the drive does not receive host interface commands from the server.

Exiting Maintenance mode

The drive must be in Function Code 0 to exit Maintenance mode.

About this task

To exit Maintenance mode:

Procedure

1. Press and hold **Unload** for 3 or more seconds to take the drive out of Maintenance mode. If no error is detected, 0 displays in the SCD, then goes blank. The drive then exits Maintenance mode and the **Ready** light turns On.
2. If an error is detected, the SCD shows an error code but still exits Maintenance mode. To determine the error, locate the code in “Drive error codes and messages” on page 41. To clear the error, turn off the power, then on again.

   Note: The drive also exits Maintenance mode automatically after it completes a maintenance function or after 10 minutes if no action occurs.

Function code 0: Maintenance mode

About this task

Function code 0 makes the drive available for running drive diagnostic tests or maintenance functions, or exiting from Maintenance mode.

Procedure

1. Place the drive in Maintenance mode. For instructions, see “Entering Maintenance mode” on page 19.
2. To exit Maintenance mode, see “Exiting Maintenance mode” on page 19.

Results

The drive exits Maintenance mode automatically after it completes a maintenance function or after 10 minutes if no action occurs.

Function code 1: Run drive diagnostics

About this task

Approximate Run Time = 5 minutes per loop

Total Number of Loops = 1

Function code 1 runs tests that determine whether the drive can properly load and unload cartridges and read and write data.

Record the time that it takes for the test to complete. Compare the recorded time with the "Approximate Run Time". If the test runs successfully but the execution time is longer than the "Approximate Run Time," run “Function code F: Write performance test” on page 27. If the Write Performance Test fails, replace the media and exit Maintenance mode.

Attention: For this test, insert only a scratch (blank) data cartridge or a cartridge that might be overwritten. During the test, the drive overwrites the data on the cartridge.

Note: If you inserted an invalid tape cartridge, error code J or 7 appears in the SCD. If you inserted a write-protected cartridge, or the media has read-only compatibility, error code P appears in the SCD. In either case, the tape drive unloads the cartridge and exits Maintenance mode after the cartridge is removed.

Steps to Run Drive Diagnostic Tests:

Procedure

1. Place the drive in Maintenance mode. For instructions, see “Entering Maintenance mode” on page 19.
2. Press **Unload** once per second until 1 displays in the SCD. (If you cycle past the wanted code, press **Unload** once per second until the code reappears.)
3. Press and hold **Unload** for 3 or more seconds, then release it to select function 1. Wait for the SCD to change to a flashing C, requesting a cartridge.
4. Insert a scratch (blank) data cartridge. The SCD changes to a flashing 1 and the test begins. During the test, the drive unloads and loads the cartridge. Do not remove the cartridge during the test.
   - If no error is detected, the diagnostic test loops and begin again. To stop the loop, press **Unload** for 1 second and release. When the loop ends, 0 temporarily displays in the SCD, and the tape drive exits Maintenance mode.
   - If an error is detected, the **Fault** light flashes and the drive posts an error code to the SCD. To determine the error, locate the code in Table 18 on page 41. To clear the error either turn the power off and then on again, or reboot the drive by pressing and holding **Unload** for 10 seconds.

Function code 2: Update drive firmware from FMR tape

About this task

Attention: When drive firmware is updated, do not turn the drive off until the update is complete or the firmware might be lost.

Function code 2 loads drive firmware from a field microcode replacement (FMR) tape. The FMR tape must be created from an LTO Ultrium 8 tape drive with the same host interface (SAS or Fibre Channel).

Procedure

1. Place the drive in Maintenance mode. For instructions, see "Entering Maintenance mode" on page 19.
2. Press **Unload** once per second until 2 displays in the SCD. (If you cycle past the wanted code, press **Unload** once per second until the code reappears.)
3. Press and hold **Unload** for 3 or more seconds, then release it to select the function. The SCD changes to a flashing C, requesting a cartridge.
4. Insert the FMR tape cartridge. The SCD changes to a flashing 2. The **Fault** light is ON solid during tape movement and flashing while code is being loaded. The **Ready** light is OFF. The tape drive loads the updated firmware from the FMR tape into its erasable programmable read-only memory (EPROM) area.
   - If the update completes successfully, the tape drive rewinds and unloads the FMR tape, resets itself, and is ready to use the new firmware. The drive automatically reboots.
   - If the update fails, the tape drive posts an error code to the SCD. To determine the error, locate the code in Table 18 on page 41. The drive then unloads the FMR tape and exits Maintenance mode after the cartridge is removed. Contact IBM technical support for problem determination or machine replacement.

Function code 3: Create FMR tape

About this task

Function code 3 copies the drive's field microcode replacement (FMR) data to a scratch data cartridge. The resulting FMR tape is used only to update the firmware on other LTO Ultrium 8 tape drives with the same host interface (SAS or Fibre Channel).

Attention: For this function, insert only a scratch (blank) data cartridge or a cartridge that might be overwritten. During the test, the drive overwrites the data on the cartridge.

Note: If you inserted an invalid tape cartridge, error code J or 7 appears in the SCD. If you inserted a write-protected cartridge, or the media has read-only compatibility, error code P appears in the SCD. In either case, the tape drive unloads the cartridge and exits Maintenance mode after the cartridge is removed.

Procedure

1. Place the drive in Maintenance mode. For instructions, see "Entering Maintenance mode" on page 19.
2. Press **Unload** once per second until 3 appears in the SCD. (If you cycle past the wanted code, press **Unload** once per second until the code reappears.).
3. Press and hold **Unload** for 3 or more seconds, then release it to select the function. The SCD changes to a flashing C, requesting a cartridge.
4. Insert a scratch (blank) data cartridge that is not write protected (or the tape drive exits Maintenance mode). The SCD changes to a flashing 3. The tape drive copies the FMR data to the scratch data cartridge.
   - If the tape drive creates the FMR tape successfully, it rewinds and unloads the new tape, exits Maintenance mode, and the tape is ready to use.

- If the tape drive fails to create the FMR tape, it displays an error code. To determine the error, see Table 18 on page 41. The tape drive then unloads the FMR tape, and exits Maintenance mode after the cartridge is removed.

Function code 4: Force a drive dump

About this task

Function code 4 completes a memory dump of data that is collected by the drive (this process is also known as saving a microcode trace).

Procedure

1. Place the drive in Maintenance mode. For instructions, see "Entering Maintenance mode" on page 19.
2. Press **Unload** once per second until 4 displays in the SCD. (If you cycle past the wanted code, press **Unload** once per second until the code reappears.)
3. Press and hold **Unload** for 3 or more seconds, then release it to select the function. The drive completes the memory dump. The SCD shows 0, then goes blank, and the drive exits Maintenance mode. To access the contents of the memory dump, see "Function code 5: Copy drive dump" on page 22.

   Note: You can also force a drive dump when the tape drive is in normal operating mode. Press and hold **Unload** for 10 seconds. This action causes the drive to reboot.

Function code 5: Copy drive dump

About this task

Function code 5 copies data from a drive memory dump (captured in Function Code 4) to the beginning of a scratch (blank) data cartridge.

Attention: For this function, insert only a scratch (blank) data cartridge or a cartridge that might be overwritten. During the test, the drive overwrites the data on the cartridge.

Note: If you inserted an invalid tape cartridge, error code J or 7 appears in the SCD. If you inserted a write-protected cartridge, or the media has read-only compatibility, error code P appears in the SCD. In either case, the tape drive unloads the cartridge and exits Maintenance mode after the cartridge is removed.

Procedure

1. Place the drive in Maintenance mode. For instructions, see "Entering Maintenance mode" on page 19.
2. Press **Unload** once per second until 5 displays in the SCD. If you cycle past the wanted code, press **Unload** once per second until the code reappears.
3. Press and hold **Unload** for 3 or more seconds, then release it to select the function.
4. Press **Unload** once per second to cycle through the following functions:
   - 5-0: no function
   - 5-1: copy memory dump to tape; clears RAM memory dump
   - 5-2: copy memory dump to flash memory; clears RAM memory dump
   - 5-3: erase flash memory

If you cycle past the wanted code, press **Unload** once per second until the code reappears.

5. Press and hold **Unload** for 3 or more seconds, then release it to select one of the functions.
6. If you selected 5-0 the drive exits Maintenance mode. If you selected 5-2 or 5-3 the SCD changes to a flashing 5 while the procedure is completing. After the procedure is completed the drive exits Maintenance mode. If you selected 5-1 the SCD changes to a flashing C indicating that a data cartridge is to be inserted.
7. Insert a scratch (blank) data cartridge within 60 seconds, or the drive exits Maintenance mode. Ensure that the scratch cartridge is not write protected, or the tape drive exits Maintenance mode. The SCD flashes the selection number while the function is completing.
   - If the copy operation completes successfully, the tape drive rewinds and unloads the tape, and exits Maintenance mode after the cartridge is removed.
   - If the copy operation fails, an error code displays in the SCD. To determine the error, locate the code in Table 18 on page 41. The tape drive unloads the tape cartridge and exits Maintenance mode after the cartridge is removed.

Function code 6: Run host interface wrap test

About this task

Approximate Run Time = 10 seconds per loop

Number of Loops = This test runs until stopped by pressing **Unload**.

Function code 6 checks the host interface circuitry and host connector on the drive.

Procedure

1. Make sure that the host interface wrap plug is connected to the host interface connector at the rear of the drive.[1].
   - Connect the wrap plug to the SAS port to be tested.
2. Place the drive in Maintenance mode. For instructions, see “Entering Maintenance mode” on page 19.
3. Press **Unload** once per second until 6 appears in the SCD.
   - To test the SAS interface on the drive,
     a. Index through the Maintenance mode options until 6 appears in the SCD.
     b. Press and hold **Unload** for 3 seconds to select Function code 6.
     c. After Function code 6 is selected, the SCD displays option 6 - 1.
     d. Press **Unload** within 5 seconds to make a different selection. If no other selection is made, the drive completes option 6 - 1.
4. Continue to press **Unload** once per second to cycle through the following functions:

- 6 - 1: test the primary SAS port
- 6 - 2: test the secondary SAS port[2]
- 6 - 3: test both primary and secondary SAS ports at the same time (requires a wrap plug in both ports)[2]
- 6 - 0: exit

5. Press and hold **Unload** for 3 or more seconds, then release it to select one of the functions. The drive automatically starts the test. If you cycle past the wanted code, press **Unload** once per second until the code reappears.
6. The SCD displays a flashing 6 during the test.
   - If no error is detected, the diagnostic test loops and begin again. To stop the loop, press **Unload** for 1 second and release. When the loop ends, 0 temporarily displays in the SCD, and the tape drive exits Maintenance mode.
   - If an error is detected, the **Fault** light flashes and the drive posts an error code to the SCD. To determine the error, locate the code in Table 18 on page 41. To clear the error either turn the power off and then on again, or reboot the drive by pressing and holding **Unload** for 10 seconds.

   Note: [1]Not supported on the USB port. [2]Not supported on the SAS/USB drive.

Function code 7: Run RS-422 wrap test

About this task

Note: This function is described here for information only. It is not supported on the IBM TS2260, TS2270, or the TS2280 tape drive.

This test causes the drive to process a check of the circuitry and connector for the RS-422 interface. This connector supports the Library Drive Interface (LDI) and the Automation Drive Interface (ADI).

Before this function is selected, attach an LDI or RS-422 wrap plug to the drive 's LDI or RS-422 connector (in place of the LDI or RS-422 cable).

Procedure

1. Make sure that no cartridge is in the drive, and the appropriate wrap plug is attached to the RS-422 connector.
2. Place the drive in Maintenance mode. For instructions, see “Entering Maintenance mode” on page 19.
3. Press **Unload** once per second until 7 appears in the Single-character Display (SCD). If you cycle past 7, continue to press **Unload** until the code is displayed again.
4. To select the function, press and hold **Unload** for 3 seconds. After you select the function, 7 flashes and the drive automatically starts the test.
   - If no error is detected, the diagnostic test loops and begin again. To stop the loop, press **Unload** for 1 second and release. When the loop ends, 0 temporarily displays in the SCD, and the tape drive exits Maintenance mode.
   - If an error is detected, the **Fault** light flashes and the drive posts an error code to the SCD. To determine the error, locate the code in Table 18 on page 41. To clear the error either turn the power off and then on again, or reboot the drive by pressing and holding **Unload** for 10 seconds.

Function code 8: Unmake FMR tape

About this task

Function code 8 erases the field microcode replacement (FMR) data and rewrites the cartridge memory on the tape. This action converts the cartridge into a valid scratch (blank) data cartridge.

Procedure

1. Place the drive in Maintenance mode. For instructions, see “Entering Maintenance mode” on page 19.

2. Press **Unload** once per second until 8 appears in the SCD. (If you cycle past the wanted code, press **Unload** once per second until the code reappears.)
3. Press and hold **Unload** for 3 or more seconds, then release it to select function 8. The SCD changes to a flashing C, requesting a cartridge.
4. Insert the FMR data cartridge (or the tape drive exits Maintenance mode). The SCD changes to a flashing 8. The tape drive erases the firmware on the tape and rewrites the header in the cartridge memory to change the cartridge to a valid scratch (blank) data cartridge: The drive then ejects the cartridge and exits Maintenance mode.

   Note: If you inserted an invalid tape cartridge, error code J or 7 appears in the SCD. If you inserted a write-protected cartridge, or the media has read-only compatibility, error code P appears in the SCD. In either case, the tape drive unloads the cartridge and exits Maintenance mode after the cartridge is removed.

   - If the tape drive creates the scratch tape successfully, it rewinds and unloads the new tape, exits Maintenance mode, and the tape is ready to use.
   - If the tape drive fails to create the scratch tape, it displays an error code. To determine the error, see Table 18 on page 41. The tape drive then unloads the FMR tape, and exits Maintenance mode after the cartridge is removed.

Function code 9: Display error code log

About this task

Function code 9 displays the last 10 error codes, one at a time (the codes are ordered; the most recent is presented first and the oldest is presented last). If there are no errors in the log, function code 0 displays in the Single-character Display (SCD) and exits Maintenance mode.

Procedure

1. Place the drive in Maintenance mode. For instructions, see “Entering Maintenance mode” on page 19.
2. Press **Unload** once per second until 9 appears in the SCD. (If you cycle past the wanted code, press **Unload** once per second until the code reappears.)
3. Press and hold **Unload**, then release it to view the most recent error code.
4. Press and release **Unload** again to view successive error codes. Allow 2 - 3 seconds pass between each depression. The **Ready** light and **Fault** light flash On/Off once for each successive error code. The SCD displays 0 when all the error codes are displayed.
5. After all error codes are viewed, exit this function by pressing **Unload** again. The SCD displays 0 and exits Maintenance mode.

Function code A: Clear error code log

About this task

Function code A erases the contents of the error code log.

Procedure

1. Place the drive in Maintenance mode. For instructions, see “Entering Maintenance mode” on page 19.

2. Press **Unload** once per second until A displays in the SCD. (If you cycle past the wanted code, press **Unload** once per second until the code reappears.)
3. Press and hold **Unload** for 3 or more seconds, then release it to select the function. A flashes in the SCD, followed by 0. The tape drive erases all errors from the error code log and exits Maintenance mode.

Function code C: Insert cartridge into tape drive

About this task

This function cannot be selected by itself, but is part of other maintenance functions (such as **Run tape drive diagnostics** and **Create FMR tape**) that require a tape cartridge to be inserted.

Function code E: Test cartridge & media

About this task

Approximate Run Time = 15 minutes per loop

Total Number of Loops = 10

Function code E completes tests that determine whether a suspect cartridge and its magnetic tape are acceptable.

Press **Unload** to stop the diagnostic test and exit Maintenance mode. Pressing **Unload** once stops the test at the end of the current test loop. Pressing **Unload** twice stops the test immediately. Wait for the drive to rewind the tape and unload the cartridge.

Attention: When you complete this test, data on the suspect tape is overwritten.

Note: If you inserted an invalid tape cartridge, error code J or 7 appears in the SCD. If you inserted a write-protected cartridge, or the media has read-only compatibility, error code P appears in the SCD. In either case, the tape drive unloads the cartridge and exits Maintenance mode after the cartridge is removed.

Procedure

1. Place the drive in Maintenance mode. For instructions, see “Entering Maintenance mode” on page 19.
2. Press **Unload** once per second until E displays in the SCD. (If you cycle past the wanted code, press **Unload** once per second until the code reappears.)
3. Press and hold **Unload** for 3 or more seconds, then release it to select the function. The SCD changes to a flashing C, requesting a cartridge.
4. Ensure that the write-protect switch on the cartridge is off, then insert the cartridge (or the tape drive exits Maintenance mode). The SCD changes to a flashing E. The tape drive runs the tests.
   - If no error is detected, the diagnostic test loops and begin again. To stop the loop, press **Unload** for 1 second and release. When the loop ends, 0 temporarily displays in the SCD, and the tape drive exits Maintenance mode.
   - If an error is detected, the **Fault** light flashes and the drive posts an error code to the SCD. To determine the error, locate the code in Table 18 on page 41. To clear the error either turn the power off and then on again, or reboot the drive by pressing and holding **Unload** for 10 seconds.

Function code F: Write performance test

About this task

Approximate Run Time = 7 minutes per loop

Total Number of Loops = 10

Function code F performs tests to ensure that the drive can read from and write to tape.

Press **Unload** to stop the diagnostic test and exit Maintenance mode. Pressing **Unload** once stops the test at the end of the current test loop. Pressing **Unload** twice stops the test immediately. Wait for the drive to rewind the tape and unload the cartridge.

Attention: For this test, insert a scratch (blank) data cartridge or a cartridge that can be overwritten. During the test, the drive overwrites the data on the cartridge.

Note: If you inserted an invalid tape cartridge, error code J or 7 appears in the SCD. If you inserted a write-protected cartridge, or the media has read-only compatibility, error code P appears in the SCD. In either case, the tape drive unloads the cartridge and exits Maintenance mode after the cartridge is removed.

Procedure

1. Place the drive in Maintenance mode. For instructions, see “Entering Maintenance mode” on page 19.
2. Press **Unload** once per second until F displays in the SCD. (If you cycle past the wanted code, press **Unload** once per second until the code reappears.)
3. Press and hold **Unload** for 3 or more seconds, then release it to select the function. The SCD changes to a flashing C, requesting a cartridge.
4. Insert a scratch (blank) data cartridge. The SCD changes to a flashing F and the tape drive runs the tests.
   - If no error is detected, the diagnostic test loops and begin again. To stop the loop, press **Unload** for 1 second and release. When the loop ends, 0 temporarily displays in the SCD, and the tape drive exits Maintenance mode.
   - If an error is detected, the **Fault** light flashes and the drive posts an error code to the SCD. To determine the error, locate the code in Table 18 on page 41. To clear the error either turn the power off and then on again, or reboot the drive by pressing and holding **Unload** for 10 seconds.

Function code H: Test head

About this task

Approximate Run Time = 12 minutes per loop

Total Number of Loops = 10

Function code H completes tests to ensure that the tape drive's head and tape-carriage mechanics work correctly.

When you begin this test, the diagnostic test begins the loop sequence. Time the first loop by pressing **Unload** once to stop the diagnostic test after the completion of the first loop, then record the time that it takes for the test to complete. Compare the recorded time with the "Approximate Run Time". If the test runs successfully but the execution time is longer than the "Approximate Run Time", run “Function code F: Write performance test” on page 27. If the Write Performance Test fails, replace the media and exit Maintenance mode.

Press **Unload** to stop the diagnostic test and exit Maintenance mode. Pressing **Unload** once stops the test at the end of the current test loop. Pressing **Unload** twice stops the test immediately. Wait for the drive to rewind the tape and unload the cartridge.

Attention: For this test, insert a scratch (blank) data cartridge or a cartridge that can be overwritten. During the test, the drive overwrites the data on the cartridge.

Note: If you inserted an invalid tape cartridge, error code J or 7 appears in the SCD. If you inserted a write-protected cartridge, or the media has read-only compatibility, error code P appears in the SCD. In either case, the tape drive unloads the cartridge and exits Maintenance mode after the cartridge is removed.

Procedure

1. Place the drive in Maintenance mode. For instructions, see "Entering Maintenance mode" on page 19.
2. Press **Unload** once per second until H displays in the SCD. (If you cycle past the wanted code, press **Unload** once per second until the code reappears.)
3. Press and hold **Unload** for 3 or more seconds, then release it to select the function. The SCD changes to a flashing C, requesting a cartridge.
4. Insert a scratch (blank) data cartridge. The SCD changes to a flashing H. The tape drive runs the tests.
   - If no error is detected, the diagnostic test loops and begin again. To stop the loop, press **Unload** for 1 second and release. When the loop ends, 0 temporarily displays in the SCD, and the tape drive exits Maintenance mode.
   - If an error is detected, the **Fault** light flashes and the drive posts an error code to the SCD. To determine the error, locate the code in Table 18 on page 41. To clear the error either turn the power off and then on again, or reboot the drive by pressing and holding **Unload** for 10 seconds.

Function code J: Fast read/write test

About this task

Approximate Run Time = 7 minutes per loop

Total Number of Loops = 10

Function code J completes tests to ensure that the drive can read from and write to tape.

When you begin this test, the diagnostic test begins the loop sequence. Time the first loop by pressing **Unload** once to stop the diagnostic test after the completion of the first loop, then record the time that it takes for the test to complete. Compare the recorded time with the "Approximate Run Time". If the test runs successfully but the execution time is longer than the "Approximate Run Time", run "Function code F: Write performance test" on page 27. If the Write Performance Test fails, replace the media and exit Maintenance mode.

Press **Unload** to stop the diagnostic test and exit Maintenance mode. Pressing **Unload** once stops the test at the end of the current test loop. Pressing **Unload** twice stops the test immediately. Wait for the drive to rewind the tape and unload the cartridge.

Attention: For this test, insert a scratch (blank) data cartridge or a cartridge that can be overwritten. During the test, the drive overwrites the data on the cartridge.

Note: If you inserted an invalid tape cartridge, error code J or 7 appears in the SCD. If you inserted a write-protected cartridge, or the media has read-only compatibility, error code P appears in the SCD. In either case, the tape drive unloads the cartridge and exits Maintenance mode after the cartridge is removed.

Procedure

1. Place the drive in Maintenance mode. For instructions, see “Entering Maintenance mode” on page 19.
2. Press **Unload** once per second until J displays in the SCD. (If you cycle past the wanted code, press **Unload** once per second until the code reappears.)
3. Press and hold **Unload** for 3 or more seconds, then release it to select the function. The SCD changes to a flashing C, requesting a cartridge.
4. Insert a scratch (blank) data cartridge. The SCD changes to a flashing J and the tape drive runs the tests.
   - If no error is detected, the diagnostic test loops and begin again. To stop the loop, press **Unload** for 1 second and release. When the loop ends, 0 temporarily displays in the SCD, and the tape drive exits Maintenance mode.
   - If an error is detected, the **Fault** light flashes and the drive posts an error code to the SCD. To determine the error, locate the code in Table 18 on page 41. To clear the error either turn the power off and then on again, or reboot the drive by pressing and holding **Unload** for 10 seconds.

Function code L: Load/unload test

About this task

Approximate Run Time = 30 seconds per loop

Total Number of Loops = 10

Function code L tests the drive's ability to load and unload a tape cartridge.

Press **Unload** to stop the diagnostic test and exit Maintenance mode. Pressing **Unload** once stops the test at the end of the current test loop. Pressing **Unload** twice stops the test immediately. Wait for the drive to rewind the tape and unload the cartridge.

Attention: Even though no data is written during this test, it is recommended that you use a blank (scratch) cartridge for this test.

Note: If you inserted an invalid tape cartridge, error code J or 7 appears in the SCD. If you inserted a write-protected cartridge, or the media has read-only compatibility, error code P appears in the SCD. In either case, the tape drive unloads the cartridge and exits Maintenance mode after the cartridge is removed.

Procedure

1. Place the drive in Maintenance mode. For instructions, see “Entering Maintenance mode” on page 19.
2. Press **Unload** once per second until L displays in the SCD. (If you cycle past the wanted code, press **Unload** once per second until the code reappears.)
3. Press and hold **Unload** for 3 or more seconds, then release it to select the function. The SCD changes to a flashing C, requesting a cartridge.
4. Insert a scratch (blank) data cartridge. The SCD changes to a flashing L and the tape drive runs the tests.
   - If no error is detected, the diagnostic test loops and begin again. To stop the loop, press **Unload** for 1 second and release. When the loop ends, 0 temporarily displays in the SCD, and the tape drive exits Maintenance mode.

- If an error is detected, the **Fault** light flashes and the drive posts an error code to the SCD. To determine the error, locate the code in Table 18 on page 41. To clear the error either turn the power off and then on again, or reboot the drive by pressing and holding **Unload** for 10 seconds.

Function code P: Post Error Reporting enabled

About this task

When **Post Error Reporting** is enabled, deferred-check conditions are reported to the host and temporary errors are reported in the sense data. Function code P is displayed in Maintenance mode when the drive has **Post Error Reporting** enabled.

This selection is normally used as a request from support personnel.

Procedure

1. Place the drive in Maintenance mode. For instructions, see "Entering Maintenance mode" on page 19.
2. Press **Unload** once per second until either P or U displays in the SCD. P or U displays in the SCD to indicate the current setting for **Post Error Reporting**. If you cycle past the desired code, press **Unload** once per second until the code reappears.
3. Exit Maintenance mode if you do not want to change the current setting for **Post Error Reporting**. For instructions, see "Exiting Maintenance mode" on page 19.
4. To disable **Post Error Reporting**, press and hold **Unload** for 3 seconds while P displays in the SCD. The SCD changes to U after you release **Unload**.
5. Press **Unload** once per second to select another Maintenance mode function. To exit Maintenance mode, refer to "Exiting Maintenance mode" on page 19.

Function code U: Post Error Reporting disabled

About this task

When **Post Error Reporting** is disabled, deferred-check conditions are not reported to the host and temporary errors are not reported in the sense data. This setting is normal (default) for the drive. When **Post Error Reporting** is disabled, Function code U is displayed in Maintenance mode. The drive defaults to **Post Error Reporting** disabled after a reboot or power off/on cycle.

Procedure

1. Place the drive in Maintenance mode. For instructions, see "Entering Maintenance mode" on page 19.
2. Press **Unload** once per second until either P or U displays in the SCD. P or U displays in the SCD to indicate the current setting for **Post Error Reporting**. If you cycle past the wanted code, press **Unload** once per second until the code reappears.
3. Exit Maintenance mode if you do not want to change the current setting for **Post Error Reporting**. For instructions, see "Exiting Maintenance mode" on page 19.
4. To disable **Post Error Reporting**, press and hold **Unload** for 3 seconds while P displays in the SCD. The SCD changes to U after you release **Unload**.
5. Press **Unload** once per second to select another Maintenance mode function. To exit Maintenance mode, refer to "Exiting Maintenance mode" on page 19.

Troubleshooting

Use the information in this section to troubleshoot any issues with your library setup and configuration.

How the drive reports problems

Drive errors can be found using one or more of the following ways:

- Front panel SCD indicator
- Error code log
- Host messages may include sense data (link) from the drive. Utilize this information along with the SCSI Reference (link) to determine the error.
- Drive log (can be downloaded using ITDT-GE)

Running drive tests

Drive tests helps in determining any problems with the drive.

A drive can be tested using one or more of the following methods:

- **Maintenance Functions**
  - **Run Drive Diagnostics**: Runs tests to determine whether the drive can properly load and unload cartridges, and read and write data.
  - **Write Performance Test**: Completes tests to ensure that the drive can read from and write to tape.
  - **Fast Read/Write Test**: Completes tests to ensure that the drive can read from and write to tape.
- **ITDT**
  - **Health Test**: Check whether the tape device is defective and output a pass/fail result.

Downloading drive log

To retrieve a drive log, utilize one of the methods described in the following sections:

Downloading drive log through the host interface

1. Open ITDT-GE.
2. For further instructions, see Dump.

Downloading drive log with the Ethernet port - Service only

Tip: The drive uses a limited version of FTP protocol to communicate on the Ethernet interface. Use a simple, command-line FTP session, such as the DOS command line, to communicate with the drive.

1. Connect an Ethernet patch cable to the drive's Ethernet interface and to a computer. To meet electromagnetic immunity requirements, a shielded Ethernet cable is required.
2. Create an FTP session between the drive and the computer. The drive 's IP address: 169.254.0.3
3. At the user prompt, type `guest` and press **Enter**.
4. At the password prompt, press **Enter**. No response is needed.
5. Type `bin` to set the communication mode to binary.
6. Type `mget *.dmp` to transfer a drive memory dump to the computer. If a memory dump exists, the drive shows you the memory dump name and ask if you want to transfer it to the computer. Type y to transfer the existing memory dump or n to skip this dump file. Then, the drive asks if you want a

forced memory dump. Type y to force a memory dump and to transfer the forced memory dump to the computer, or type n to skip forcing a memory dump.

7. Type `quit` to end the FTP session.
8. Remove Ethernet patch cable from the drive's Ethernet interface and the computer.

Troubleshooting guide

About this task

Table 13. Tape drive problems

Problem	Action
Drive has no power	1. Try a different electrical outlet or power cord. 2. Refer to Pre-call checklist. If this doesn't help, contact IBM technical support.
Cooling fan not working	Refer to Pre-call checklist. If this doesn't help, contact IBM technical support.
SCD and fault light indicting an error	1. See “Drive error codes and messages” on page 41 for any possible errors. 2. Update firmware. 3. Refer to Pre-call checklist. If this doesn't help, contact IBM technical support.

Table 13. Tape drive problems (continued)

Problem	Action
Can’t write to or read from tape	• Make sure that the cartridge isn’t a WORM cartridge that was already used. • Make sure that the cartridge is write enabled (move the write-protect switch to the enabled position). • Make sure that the data cartridge is compatible with the drive model. See “Media compatibility” on page 8. • Make sure that you’re using an LTO cartridge that isn’t degaussed.  **CAUTION:** Don’t degauss LTO cartridges! • Make sure that the cartridge wasn’t exposed to harsh environmental or electrical conditions and isn’t physically damaged in any way. • Many backup applications don’t read or write to cartridges that were created with a different backup application. In this case, you might need to run an erase, format, or label operation on the cartridge. • Make sure that you understand any data protection or overwrite protection schemes that your backup application might be using, which might prevent you from writing to a specific cartridge. • Retry the operation with a different, known good tape. • Clean the tape drive.
Tape drive not communicating with the server	1. Ensure that the communication path between the host and the drive is functioning properly. See Host not communicating with drive. If your problem is not resolved, go to next step. 2. Refer to Pre-call checklist. If this doesn't help, contact IBM technical support.

Table 14. Cartridge problems	
Problem	**Solution**

Cartridge failing to load and unload properly	**Note:**
	• The tape drive must rewind the tape before it is ejected. The amount of time for this procedure can vary, depending on how the tape was used. See “Drive information” on page 1.
	• The tape drive performs media optimization on the first load of a cartridge. The amount of time for this procedure can vary. See “Drive information” on page 1.
	Follow these instructions for removing tape from the tape drive:
	1. Stop all host activity.
	2. Check drive status by using any of the following methods:
	  • SCD display
	  • ITDT
	  • Indicator lights on a library if the drive is installed in a library
	3. If the drive is in the middle of performing an operation, wait until the drive is idle before attempting any further steps.
	4. Attempt to unload the cartridge.
	5. Power down the drive.
	6. Disconnect the host cable from the drive.
	7. Power on the drive, and wait until the tape drive is idle or ready.
	8. Attempt to unload the cartridge.

Table 15. Cartridge problems

Problem	Solution

Cartridge failing to load and unload properly	Follow these instructions for removing tape from the tape drive:
	
	Follow these steps to inspect a cartridge for damage:
	
	1. Check that the leader pin is attached and properly seated by opening the cartridge door and observing the pin's placement. See “Repositioning a leader pin” on page 67.
	2. Inspect the cartridge case, the cartridge door, and the write-protect switch for damage.
	3. Inspect the rear of the cartridge (the part that you load first into the tape load compartment) and ensure that there are no gaps in the seam of the cartridge case. See 1 in Figure 10 on page 66 and 4 in Figure 12 on page 68.. If there are gaps, the leader pin might be dislodged. Go to “Repositioning or reattaching a leader pin” on page 67.
	4. Try loading or unloading another tape cartridge.
	  • If it fails, contact your service representative for more problem determination.
	  • If it is successful, discard the cartridge that originally failed.
	
	Notes:
	
	• If a damaged or mishandled cartridge is the problem, see “Handling the cartridges” on page 63 for instructions about handling the media. It is possible that your other cartridges might also be damaged.
	• If your cartridge does not eject properly, contact your service representative.

Table 16. Cartridge problems

Problem	Solution
Media-related issues	To resolve problems that are related to media, the drive's firmware includes following features: • **Test Cartridge & Media** diagnostic test that verifies whether a suspect cartridge and its magnetic tape are acceptable for use. • **Statistical Analysis and Reporting System** (SARS) to help with isolating failures between media and hardware. To determine the cause of failure, SARS uses the cartridge performance history that is saved in the cartridge memory (CM) and the drive performance history that is kept in the drive's VPD (Vital Product Data) area in NVRAM. Any failures that SARS detects are reported as TapeAlert flags on the server. See *IBM LTO Ultrium Tape Drive SCSI Reference*.  **Attention:** If you insert the IBM LTO Ultrium Data Cartridge into another manufacturer's drive, the SARS data in the cartridge memory might become lost or invalid. If you encounter a media-related problem, refer to "Function code E: Test cartridge & media" on page 26.
Tape is stuck in drive	Try the following steps to remove the stuck tape. **Note:** The tape drive must rewind the tape before it's ejected. This procedure can take up to ten minutes or more, depending on how much tape must be rewound. When the tape is rewound, the eject cycle takes fewer than 16 seconds. The **Ready** light flashes while the tape rewinds. Wait for the tape to finish rewinding before another operation is attempted. 1. Stop all Host Activity. 2. Attempt to unload or move the cartridge to a slot. 3. Power down the library, disconnect the cable from the drive, power on the library, and wait until the tape drive is idle or ready. Attempt to **Move Cartridge to Slot**. 4. Attempt a **Eject Cartridge from Drive** as an emergency unload operation. **Important:** Inspect the tape cartridge that was stuck. Damage or misplaced labels on the cartridge might cause the load/unload failure. Discard any tape cartridge that is found to have issues.

Table 16. Cartridge problems (continued)	
Problem	**Solution**
A cartridge that is recently imported from a different environment is causing issues	Media that is moved from one environment to another can cause issues until it acclimates to the new conditions. A cartridge must be acclimated for at least 24 hours before it's used, particularly if it was stored at a substantially different temperature or level of humidity than the device.
Cleaning or data cartridge incompatible with drive	• Check the event log to see which cartridge is incompatible. • Make sure that you're using data and cleaning cartridges that are compatible with the drive and model of your device. • Make sure that you're using the correct cartridge type for the operation. The device automatically unloads incompatible cartridges, and the **Attention** LED flashes. • Export the media.

Table 17. Communication problems	
Problem	**Solutions**
Host not communicating with drive	Follow these steps to check physical connectivity or host to device communication: 1. Check whether the tape drive power is on. 2. Verify that the SAS or FC cable is connected properly to the server and to the tape drive. 3. Check whether the parameters for the host adapter installation are correct. 4. Verify that the host adapter is supported by the tape drive. 5. Ensure that there is a point-to-point connectivity between the server and the tape drive. SAS/FC connectivity does not support multiple drive connections (daisy-chaining of devices). 6. Check the length of the SAS or FC cable. It cannot exceed 5.5 m (18 ft). 7. Run Wrap diagnostic using ITDT. **Tip:** To thoroughly verify host-to-device communications, run Wrap diagnostic over the host interface from the host to the drive and back.

Table 17. Communication problems (continued)

Problem	**Solutions**
Host reporting interface bus error	The procedure for fixing interface bus errors varies, depending on whether the error is consistent or intermittent, and on your configuration. 1. Check whether the tape drive power is on. 2. Verify that the SAS or FC cable is connected properly to the server and to the tape drive. 3. Replace SAS or FC cable if it shows any signs of damage.
Host application reporting SCSI timeout	**Note:** • The tape drive must rewind the tape before it is ejected. The amount of time for this procedure can vary, depending on how the tape was used. See “Drive information” on page 1. • The tape drive performs media optimization on the first load of a cartridge. The amount of time for this procedure can vary. See “Drive information” on page 1. The procedure for SCSI timeouts varies depending on whether timeout is consistent or intermittent, and on your drive configuration. Follow these steps to troubleshoot a SCSI timeout: 1. Stop all Host Activity. 2. Check drive status by using any of the following methods: • SCD display • ITDT • Indicator lights on a library if the drive is installed in a library 3. If the drive is in the middle of performing an operation, wait until the drive is idle before attempting any further steps. 4. Validate that the drive has the latest firmware. 5. Check with software application provider for any updates. 6. Check whether the tape drive power is on. 7. Power down the drive. 8. Verify that the SAS or FC cable is connected properly to the server and to the tape drive. 9. Replace SAS or FC cable if it shows any signs of damage. 10. Power on the drive and wait until the tape drive is idle or ready.

Pre-call checklist

If you have questions or problems, go through this checklist before IBM technical support is contacted.

Ensure that the total SAS cable length does not exceed 5.5 m (18 ft). Complete these steps before you call IBM technical support. Where instructions refer you to the web, go tohttp://www.ibm.com/support/fixcentral.

1. Complete a general checkup of the hardware and connections:
   - Verify that all cables are connected properly at both ends.
   - Before the SAS cables are attached, ensure that the connector does not contain bent or recessed pins.
   - Ensure that all retention screws for the SAS cable are securely tightened.
2. Verify that the drive's firmware is at the most recent level. To determine the current release of firmware, go to the web. See “Updating drive firmware” on page 16 for instructions about downloading the current firmware.
3. Verify that your device drivers are at the most recent level:
   - For IBM device drivers, go to the web.
   - For the device drivers of independent software vendors (ISVs), go to the appropriate third-party website.
4. Verify whether your hardware and software configuration is supported. To determine the current supported attachments, go to the web.
5. Review "Frequently Asked Questions" and "Hints and Tips" on the web.
6. Run one of the diagnostic methods:
   - Local diagnostic tests:
     a. Run “Function code 1: Run drive diagnostics” on page 20 to determine whether the drive can properly load and unload cartridges, and read and write data. Optionally, you might run one of the following diagnostic procedures:
        - “Function code E: Test cartridge & media” on page 26 to determine whether a suspect cartridge and its magnetic tape are acceptable.
        - “Function code F: Write performance test” on page 27 to ensure that the drive can read from and write to tape.
        - “Function code H: Test head” on page 27 to ensure that the tape drive's head and tape-carriage mechanics work correctly.
        - “Function code J: Fast read/write test” on page 28 to ensure that the drive can read from and write to tape.
        - “Function code L: Load/unload test” on page 29 to test the drive's ability to load and unload a tape cartridge.

     b. Run “Function code 6: Run host interface wrap test” on page 23.
   - Remote diagnostic test:
     - With the ITDT utility, run the SCAN as described in **Verifying host interface communications**.

Contacting IBM technical support

Follow the procedures to contact IBM technical support.

Important: This tape library is a customer installed unit. The customer is responsible for the setup and maintenance of the tape library. The customer is charged for service if a service contract is not in place.

- Complete the steps in Pre-call checklist before a call is placed to IBM technical support.

- Before IBM technical support is called, the customer is responsible for following published LTO diagnostic procedures, including any needed update to the current level of firmware.
- The IBM Support Center assists with problem determination and can initiate shipment of a replacement part, if needed, to the customer's location. Transportation costs, both ways, are paid by IBM. The replacement part becomes the property of the customer in exchange for the failed part, which becomes the property of IBM. The customer is responsible for packing the failed part into the shipping carton that contained the replacement part. Failure to return the failed part to IBM within 30 days results in a bill sent to the customer for the new list price. The customer is responsible for installing and setting up all replacement parts.
- Failure to use the carton in which the replacement part was received, or failure to properly pack the returned part, can result in charges that are incurred for damage to the failed part during shipment.
- Before you call technical support, follow these steps that help you take full advantage of your call.

  1. Be prepared to provide
     - Machine type and model name
     - Serial number of the library
     - Hardware configuration, including firmware versions, drive types, number of modules
     - Type of host, operating system version, device driver information, backup software application and its version, HBA type and brand, SAN configuration - Switch make and model (if applicable)
     - A brief description of the problem
  2. Review all documentation carefully. (Experience demonstrates that most questions are answered in your documentation).
  3. Be prepared to explain whether the software or hardware worked properly anytime in the past. Have you changed anything recently?
  4. Pinpoint the exact location of your problem, if possible. Note the steps that led to the problem. Can you duplicate the problem or is it a one-time occurrence?
  5. Note any host error messages displayed. Write down the exact error message.
  6. If possible, call while at your computer, with the library installed and turned on.
- The IBM Support Center assists with problem determination and initiates shipment of a replacement part, if needed, to your location. To contact IBM technical support:
  - In the US: 1-800-IBM-SERV
  - All other Countries or Regions: https://www.ibm.com/mysupport/s/.
  - Select your country, then under **Technical Support**, click **Open Service Request**.

Diagnostic information

This section provides information on various diagnostic tools.

IBM Tape Diagnostic tool (ITDT)

ITDT has many capabilities. It is a quick, convenient, and efficient method for device firmware updates and device log downloads.

The IBM Tape Diagnostic tool (ITDT) provides following functions:

- Scans the host interface and finds and displays for selection all IBM LTO devices. The tool does not display non-IBM devices.
- Runs quick or extended diagnostic tests on tape drives. If the library is online to the server/host where the tool resides, ITDT communicates with the drive through the library to load and unload a test cartridge, exercising some library functions.
- Downloads firmware memory dumps from tape drives and libraries
- Completes a firmware update on tape drives or libraries

- Tests the performance of the environment by completely writing a cartridge and measuring performance
- Retrieves and displays cartridge information
- Verifies the encryption environment

The IBM Tape Diagnostic tool (ITDT) is available in two versions:

- **Standard Edition (ITDT-SE):** This is a command line version available for following platforms:
  - IBM AIX
  - Microsoft Windows operating systems
  - Linux operating systems
- **Graphical Edition (ITDT-GE):** This is a GUI version available for following platforms:
  - Microsoft Windows operating systems
  - Linux operating systems

Note: Be sure that you have the most current version of ITDT if you are updating firmware on a recent drive type. Before ITDT is used, verify that your library host operating system is at the current released level. This action ensures optimum read/write operations for diagnostic tests.

IBM maintains the current levels of ITDT on the web at http://www.ibm.com/support/fixcentral.

Additional information about the IBM Tape Diagnostic Tool (ITDT) is included in the IBM Tape Device Drivers and Diagnostic Tool User's Guide.

Drive error codes and messages

SCD drive error codes give descriptions of the errors and messages that pertain to the drive.

If the drive detects a permanent error, it displays the error code on the SCD and flashes the **Fault** light (**Ready** light is Off).

- Make note of the SCD error code before a cartridge is removed or the SCD error code is cleared.
- If an error occurred with a cartridge in the drive, push **Unload** to eject the cartridge.
- To clear the SCD error code and power cycle the drive, press **Unload** for 10 seconds. A drive memory dump is created.

Attention: If the drive detects a permanent error, and displays an error code other than 0, it automatically completes a drive memory dump. If you force a drive memory dump, the existing memory dump is overwritten and data is lost. After you force a drive memory dump, do not turn off the power to the drive or you might lose the memory dump data.

Table 18. Error codes on the Single-character Display

Error Code	Cause and Action
0	No error occurred and no action is required. This code displays when diagnostic tests are finished running and no error occurred. **Note:** The Single-character Display is blank during normal operation of the tape drive.

Table 18. Error codes on the Single-character Display (continued)

Error Code	Cause and Action
1	Temperature problem. The tape drive detected that the recommended operating temperature was exceeded. Complete one or more of these actions: • Ensure that the cooling fan is rotating and is quiet. If not, refer to your enclosure documentation. • Remove any blockage that prevents air from flowing freely through the tape drive. • Ensure that the operating temperature and airflow is within the specified range (see "Location requirements" on page 11). Clear the error code by power-cycling the tape drive or placing the drive in Maintenance mode. If the operating temperature and airflow are within the specified range, and the problem persists, replace the drive.
2	Power problem. The tape drive detected that the externally supplied power is outside the specified voltage limits (the tape drive is not operating). Complete this action: 1. Ensure that the power connector is properly seated. 2. Turn power off/on the tape drive to see whether the problem repeats. 3. Replace the tape drive if the problem persists. The error code clears when you place the tape drive in maintenance mode.
3	Firmware problem. The tape drive determined that a firmware error occurred. Complete this action: 1. Collect a drive memory dump. **Note:** Do not force a new memory dump; the tape drive created one. • Server's host interface with a device driver utility or system tool such as ITDT. For instructions about ITDT, visit the web at http://www.ibm.com/support/fixcentral. • Ultrium tape drive (to copy and read a drive memory dump, use "Function code 5: Copy drive dump" on page 22) 2. Power the tape drive off and on, then retry the operation that produced the error. 3. If the problem persists, download new firmware and retry the operation. 4. If the problem persists, send the drive memory dump that you collected in step 1 to your IBM Support Center. The error code clears when you place the tape drive in Maintenance mode.
4	Firmware or hardware problem. The tape drive determined that a firmware or tape drive hardware failure occurred. Complete this action: 1. Collect a drive dump. **Note:** Do not force a new memory dump; one exists. • Server's host interface with a device driver utility or system tool such as ITDT. For instructions about using ITDT, go to http://www.ibm.com/support/fixcentral. • Ultrium tape drive (to copy and read a drive memory dump, use "Function code 5: Copy drive dump" on page 22) 2. Power the tape drive off and on, then retry the operation that produced the error. The error code clears when you place the tape drive in Maintenance mode. 3. If the problem persists, download new firmware and retry the operation; if new firmware is not available, replace the drive.

Table 18. Error codes on the Single-character Display (continued)

Error Code	Cause and Action
5	Tape drive hardware problem. The drive determined that a tape path or read/write error occurred. To prevent damage to the drive or tape, you cannot insert a cartridge if the current cartridge was successfully ejected. The error code might clear when you cycle power to the tape drive or place it in maintenance mode. If the problem persists, replace the drive. **Note:** Copy the drive memory dump to flash memory before the drive is returned. For instructions, refer to "Function code 5: Copy drive dump" on page 22.
6	Tape drive or media error. The tape drive determined that an error occurred, but it cannot isolate the error to faulty hardware or to the tape cartridge. Ensure that the tape cartridge is the correct media type: • Ultrium 1, 2, 3, 4, 5, 6, 7, and M8 cartridges are not supported in the Ultrium 9 tape drive. • Drive does not accept an expired Cleaning Cartridge. • Drive does not accept a WORM cartridge when diagnostic tests are run in Maintenance mode. • Drive does not write over existing data sets on a WORM cartridge. Ensure that you are appending data sets on WORM media rather than attempting to write over existing data sets. If the tape cartridge is the correct media type, complete this action:
6	**Problems with Writing Data** If the problem occurred while the tape drive was writing data to the tape, retry the operation with a different cartridge: • If the operation succeeds, the original cartridge was defective. Copy data from the defective cartridge and discard it. • If the operation fails and another tape drive is available, insert the cartridge into the other unit and retry the operation. – If the operation fails, discard the defective cartridge. – If the operation succeeds, insert a scratch data cartridge into the first unit and run "Function code 1: Run drive diagnostics" on page 20. - If the diagnostic tests fail, replace the tape drive. - If the diagnostic tests succeed, the error was temporary. • If the operation fails and another tape drive is not available, insert a scratch data cartridge into the unit and run "Function code 1: Run drive diagnostics" on page 20. – If the diagnostic tests fail, replace the tape drive. – If the diagnostic tests succeed, discard the cartridge. If the problem occurs with multiple tape cartridges, run "Function code 1: Run drive diagnostics" on page 20: • If the diagnostic tests fail, replace the tape drive. • If the diagnostic tests succeed, run "Function code H: Test head" on page 27 . – If the diagnostic test fails, replace the tape drive. – If the diagnostic test succeeds, replace the cartridges that caused the problem. The error code clears when you remove the tape cartridge or place the tape drive in Maintenance mode.

Table 18. Error codes on the Single-character Display (continued)

Error Code	Cause and Action
6	**Problems with Reading Data** If the problem occurred while the tape drive was reading data from the tape, complete one of these procedures: • If another tape drive is available, insert the cartridge into the other unit and retry the operation: – If the operation fails, discard the defective cartridge. – If the operation succeeds, insert a scratch data cartridge into the first unit and run "Function code 1: Run drive diagnostics" on page 20: - If the diagnostic test fails, replace the tape drive. - If the diagnostic test succeeds, the error was temporary. • If another tape drive is not available, insert a scratch data cartridge into the unit and run "Function code 1: Run drive diagnostics" on page 20: – If the diagnostic test fails, replace the tape drive. – If the diagnostic test succeeds, discard the cartridge. If the problem occurs with multiple tape cartridges, run "Function code 1: Run drive diagnostics" on page 20. • If the diagnostic test fails, replace the tape drive. • If the diagnostic test succeeds, run "Function code H: Test head" on page 27. – If the diagnostic test fails, replace the tape drive. – If the diagnostic test succeeds, replace the cartridges that caused the problem. The error code clears when you remove the tape cartridge or place the tape drive in Maintenance mode.

Table 18. Error codes on the Single-character Display (continued)

Error Code	Cause and Action
7	Tape drive or media error. The tape drive determined an error occurred because of a faulty tape cartridge or an invalid tape cartridge. Ensure that the tape cartridge is the correct media type: • Ultrium 1, 2, 3, 4, 5, 6, 7, and M8 cartridges are not supported in the Ultrium 9 tape drive. • Drive does not accept an expired Cleaning Cartridge. • Drive does not accept a WORM cartridge when diagnostic tests are run in Maintenance mode. • Drive does not accept an FMR tape unless the drive is completing “Function code 8: Unmake FMR tape” on page 24. • Drive does not write over existing data sets on a WORM cartridge. Ensure that you are appending data sets on WORM media rather than attempting to write over existing data sets. • Drive does not **Create FMR tape** (Maintenance code 3) with a cartridge that is already an FMR tape. Use another cartridge or run Maintenance mode “Function code 8: Unmake FMR tape” on page 24. • Drive does not **Unmake FMR tape** (Maintenance code 8) with a cartridge that is not an FMR tape. If the tape cartridge is the correct media type, try another tape cartridge. If the problem occurs with multiple tape cartridges, use this procedure: 1. If possible, run the tape cartridge in a different tape drive. Replace the media if the operation in the other unit fails, and 6 or 7 displays. If the operation succeeds, run “Function code E: Test cartridge & media” on page 26. **Attention:** When you run the **Test Cartridge & Media** diagnostic test, data on the suspect tape is overwritten. Use only a scratch data cartridge to run the test. • If the diagnostic test fails, replace the media. • If the diagnostic test succeeds, clean the drive head (see “Cleaning the drive head” on page 89) and run “Function code 1: Run drive diagnostics” on page 20. – If the drive diagnostic test fails, replace the drive. – If the drive diagnostic test succeeds, complete the operation that produced the initial media error. The error code clears when you remove the tape cartridge or place the tape drive in Maintenance mode.
8	Interface problem. The tape drive determined that a failure occurred in the tape drive 's hardware or in the host bus. If 8 displays while "Function Code 6: Host Interface Test" was running: 1. Verify that the correct interface wrap tool was attached in the correct interface port during the test. The test fails if the correct interface wrap tool is not attached. **Note:** The interface wrap test is not supported on the USB port and displays an invalid error if run. 2. If the correct interface wrap tool was attached during the test, replace the drive. The error code clears when you place the tape drive in Maintenance mode.
9	Tape drive or RS-422 error. The tape drive determined that a failure occurred in the tape drive 's hardware or in the RS-422 connection. See “Function code 7: Run RS-422 wrap test” on page 24 or refer to the library procedures to isolate the problem to the drive. The error code clears when you place the tape drive in Maintenance mode.

Table 18. Error codes on the Single-character Display (continued)

Error Code	Cause and Action
A	Degraded operation. The tape drive determined that a problem occurred which degraded the operation of the tape drive, but it did not restrict continued use. If the problem persists, determine whether the problem is with the drive or the media. **Note:** The drive is usable, though the Single-character Display continues to indicate an error and the **Fault** light flashes. The error code might clear when you cycle power to the tape drive or place it in Maintenance mode. To determine whether the problem is with the drive hardware, or the tape media, complete these procedures: 1. If possible, run the tape cartridge in a different drive. Replace the media if the operation in the other drive fails, and 6 or 7 displays. If the operation succeeds, run the **Test Cartridge & Media** diagnostic test (see "Function code E: Test cartridge & media" on page 26). 2. If the **Test Cartridge & Media** diagnostic test fails, replace the media. If it runs successfully, clean the failing drive and run the drive diagnostic tests (see "Cleaning the drive head" on page 89 and "Function code 1: Run drive diagnostics" on page 20). When you begin this test, the diagnostic test begins the loop sequence. Time the first loop by pressing **Unload** once to stop the diagnostic test after the completion of the first loop, then record the time that it takes for the test to complete. Compare the recorded time with the "Approximate Run Time". If the test runs successfully but the execution time is longer than the "Approximate Run Time", run "Function code F: Write performance test" on page 27. If the Write Performance Test fails, replace the media and exit Maintenance mode. If the drive diagnostic tests run successfully, complete the operation that produced the initial drive error. 3. If the problem persists, replace the drive. If it is not possible to run the tape cartridge in a different drive, complete these procedures: 1. Clean the failing drive and run the drive diagnostic tests (see "Cleaning the drive head" on page 89 and "Function code 1: Run drive diagnostics" on page 20). When you begin this test, the diagnostic test begins the loop sequence. Time the first loop by pressing **Unload** once to stop the diagnostic test after the completion of the first loop, then record the time that it takes for the test to complete. Compare the recorded time with the "Approximate Run Time". If the test runs successfully but the execution time is longer than the "Approximate Run Time", run "Function code F: Write performance test" on page 27. If the Write Performance Test fails, replace the media and exit Maintenance mode. If the drive diagnostic tests run successfully, run the **Test Cartridge & Media** diagnostic test (see "Function code E: Test cartridge & media" on page 26). 2. If the **Test Cartridge & Media** diagnostic test fails, replace the media. If it runs successfully, complete the operation that produced the initial drive error. 3. If the problem persists, replace the drive.
C	The tape drive must be cleaned. Clean the tape drive. See "Cleaning the drive head" on page 89. The error code clears when you clean the tape drive or place it in Maintenance mode.
d	Fiber AL_PA conflict. Two drives on fiber loop have the same AL_PA. Modify the tape drive AL_PA to eliminate the conflict. NOT SUPPORTED ON THIS DRIVE.

Table 18. Error codes on the Single-character Display (continued)

Error Code	Cause and Action
e	Encryption Error. Displayed when the drive detects an error that is associated with an encryption operation. If the problem occurred while the tape drive was writing data to, or reading data from, tape: 1. Check the host application to ensure that the host application is providing the correct encryption key. • Refer to the *IBM LTO Ultrium Tape Drive SCSI Reference* for the sense data that is returned for an encryption operation. • Retry the encryption operation after the host application problems are resolved. 2. Check the operation of the tape drive by resetting the drive and running POST. • Refer to the error code displayed on the SCD if the drive reset and POST fails. • Retry the encryption operation if the drive reset and POST complete without errors. 3. Check the media. • Ensure that the correct media is used. Data encryption is supported by LTO Ultrium 4 and later Data Cartridges only. • Retry the encryption operation with the tape cartridge in another encryption enabled drive. Replace the media if the problem repeats with the same tape cartridge in multiple drives. If the problem occurred while the tape drive was running POST or diagnostic tests, replace the drive. The error code clears with the first attempted write/read after the encryption key is changed, or when the drive is placed in Maintenance mode.
E	Fiber Port offline. Displayed when the drive fiber port received a **`port bypass`** command from another port on the Fibre Channel network.
F	Fibre Channel error. No light is displayed if the drive fiber port does not detect light.
J	Incompatible media. The tape drive detected that an unsupported cartridge was loaded or the cartridge that is loaded has an incompatible format.
P	Write operation to a write protected cartridge was attempted (includes any attempt to overwrite a WORM protected tape). Ensure that the tape cartridge is the correct media type. If the tape cartridge is the correct media type, check the write-protect switch on the cartridge. The drive does not write to a write-protected cartridge. The error code clears when you remove the tape cartridge or place the tape drive in Maintenance mode.
C	The drive is performing media optimization.

SCD dot

If a drive dump is present while the drive is in maintenance mode, a single red dot illuminates in the lower right corner of the SCD. To download the drive dump, see Dump.

The SCD dot turns OFF when you obtain a dump or update the drive firmware.

Note: If the drive dump is stored in ROM memory (SCD dot ON solid), the dump is lost when you turn OFF the power or reset the drive.

Status lights

The status lights provide information about the status of the tape drive.

The status lights (in "Front right panel of the drive" on page 7) are light-emitting diodes (LEDs) that provide information about the state of the drive.

The **Ready** status light is green and the **Fault** status light is amber, and (when lit) solid or flashing. The **Encryption** status light is white.

Mode	SCD	Ready LED (green)	Fault LED (amber)
Operational	Blank	On	Off
Activity (tape movement) in Operational Mode	Blank	Flashing	Off
Maintenance	Solid character	Flashing	On
Executing Maintenance Selection	Flashing character	Off	On
Error Condition	Solid character	Off	Flashing
Power on / Reset Initialization	Random segments	Off	On

Note: The white Encryption status light is on when the tape drive has a cartridge that is loaded and all data on this cartridge is encrypted (excluding the label). LTO Ultrium 7 and later cartridges only.

Table 19 on page 48 lists the conditions of the status lights and Single-character Display (SCD) and provides an explanation of what each condition means.

Table 19. Meaning of status lights and single-character display (SCD)

If the green Ready Status Light is...	And the amber Fault Status Light is...	And the Encryption Status Light is...	And the SCD is...	And the SCD dot is...	Meaning
Off	Off	Off	Off	Off	The drive has no power or is powered off.
On	Off	On/Off	Off	Off	The drive is powered on and in an idle state. **Note:** If a cartridge is loaded, the white Encryption status light is on when all the data on the cartridge is encrypted (excluding the label). LTO Ultrium 7 and later cartridges only.
Flashing (once per second)	Off	On/Off	Off	Off	The drive is reading from the tape, writing to the tape, rewinding the tape, locating data on the tape, loading the tape, or unloading the tape. **Note:** The white Encryption status light is on when all the data on the cartridge is encrypted (excluding the label). LTO Ultrium 7 and later cartridges only.

Table 19. Meaning of status lights and single-character display (SCD) (continued)

If the green Ready Status Light is...	And the amber Fault Status Light is...	And the Encryption Status Light is...	And the SCD is...	And the SCD dot is...	Meaning
Flashing (once per second)	Off	Off	Off	Off	If the drive contains a cartridge during the power-on cycle, the drive completes POST and slowly rewinds the tape. The process might take up to 13 minutes. The light stops flashing and becomes solid when the drive completes the recovery and is ready for a read or write operation. To eject the cartridge, press **Unload**.
Off	On	Off	Displaying an error code or Maintenance Mode Function	On/Off	The drive is displaying error codes from the error code log on the SCD. For more information, see "Function code 9: Display error code log" on page 25 and "Drive error codes and messages" on page 41.
On/Off	On/Off	On/Off	Displaying random segments/ Blank/ displaying random segments/ displaying 8/Blank	On/Off	During power-on, or a drive reset, the drive front panel displays drive progress as follows: 1. SCD displays random segments (no Lights ON). 2. SCD displays random segments (Ready light ON). 3. SCD displays random segments (Fault light ON). 4. SCD displays [8] (Ready, Fault, Encryption, and SCD dot lights ON). 5. SCD goes blank (Ready light ON) after a successful power-on or reset. If an error is detected during the power-on or reset, the tape drive posts an error code to the SCD. To determine the error, locate the code in "Drive error codes and messages" on page 41.
Off	On	Off	0	On/Off	The drive is entering or exiting from Maintenance mode. For more information, see "Function code 0: Maintenance mode" on page 19.
Off	On	Off	Flashing selected function	On/Off	The drive is running the selected function while in Maintenance mode.

Table 19. Meaning of status lights and single-character display (SCD) (continued)

If the green Ready Status Light is...	And the amber Fault Status Light is...	And the Encryption Status Light is...	And the SCD is...	And the SCD dot is...	Meaning
Off	Flashing (once per second)	Off	Displaying error code	Off	An error occurred and the drive or media might require service, or it might require cleaning. Make a note of the code on the SCD, then see "Drive error codes and messages" on page 41 to determine the action that is required.
Off	Flashing	Off	Displaying C	Off	The drive needs cleaning.
Off	Flashing	Off	Displaying Function Code 2 or Flashing	Off	The drive is updating firmware.[1] With an FMR cartridge the SCD displays a 2. The SCD is off with the host interface. For more information, see "Updating drive firmware" on page 16.
Off	Flashing (twice per second)	Off	Off	Off	The drive detected an error and is completing a firmware recovery. It resets automatically.
Off	On	Off	Flashing C	Off	The drive is requesting a cartridge to be loaded.
Off	Flashing (twice per second)	Off	Off	On	There is a drive memory dump in flash memory.

[1] Power must not be removed from the drive until the microcode update is complete. The drive indicates that the update is complete by resetting and completing POST.

TapeAlert flags supported by the drive

Flag Number	Flag Name	Hex Code	Description	Action Required	Event
1	Read warning	01h	Set when the tape drive is having problems reading data. No data is lost, but there is a reduction in the performance of the tape.	Isolate the fault between drive and tape by following these steps: • Use a known good tape cartridge in the suspect drive. If the drive fails, contact your IBM® Service Representative. • Use the suspect tape cartridge in a known good drive. If the test fails, discard the cartridge.	Warning Event

Flag Number	Flag Name	Hex Code	Description	Action Required	Event
2	Write warning	02h	Set when the tape drive is having problems writing data. No data is lost, but there is a reduction in the performance of the tape.	Isolate the fault between drive and tape by following these steps: • Use a known good tape cartridge in the suspect drive. If the drive fails, contact your IBM® service representative. • Use the suspect tape cartridge in a known good drive. If the test fails, discard the cartridge.	Warning Event
3	Hard error	03h	Set for any unrecoverable read, write, or positioning error. (This flag is set with flags 4, 5, or 6).	See the **Action Required** column for Flag Number 4, 5, or 6 in this table. Ensure that tape drive firmware is at the latest version.	Warning Event
4	Media	04h	Set for any unrecoverable read, write, or positioning error that is due to a faulty tape cartridge.	Replace the tape cartridge.	Warning Event
5	Read failure	05h	Set for any unrecoverable read error where isolation is uncertain and failure might be due to a faulty tape cartridge or to faulty drive hardware.	If Flag Number 4 is also set, the cartridge is defective. Replace the tape cartridge. If Flag Number 4 is not set, see Error Code 6 in "Single-character display (SCD)" on page 92.	Warning Event
6	Write failure	06h	Set for any unrecoverable write or positioning error where isolation is uncertain and failure might be due to a faulty tape cartridge or to faulty drive hardware.	If Flag Number 9 is also set, make sure that the write-protect switch is set so that data can be written to the tape. If Flag Number 4 is also set, the cartridge is defective. Replace the tape cartridge. If Flag Number 4 is not set, see Error Code 6 in "Single-character display (SCD)" on page 92.	Warning Event
7	Media life	07h	Set when the tape cartridge reaches its end of life (EOL).	1. Copy the data to another tape cartridge. 2. Discard the old (EOL) tape.	Warning Event
8	Not data grade	08h	Set when the cartridge is not data-grade. Any data that you write to the tape is at risk.	Replace the tape with a data-grade tape.	Warning Event
9	Write protect	09h	Set when the tape drive detects that the tape cartridge is write-protected.	Make sure that the cartridge's write-protect switch is set so that the tape drive can write data to the tape.	Warning Event

Flag Number	Flag Name	Hex Code	Description	Action Required	Event
10	No removal	0Ah	Set when the tape drive receives an **UNLOAD** command after the server prevented the tape cartridge from being removed.	Refer to the documentation for your server's operating system.	Info Event
11	Cleaning media	0Bh	Set when you load a cleaning cartridge into the drive.	No action is required. Informational message only.	Info Event
12	Unsupported format	0Ch	Set when you load an unsupported cartridge type into the drive or when the cartridge format is corrupted.	Use a supported tape cartridge.	Info Event
13	Recoverable mechanical cartridge failure	0Dh	The drive has detected a mechanical volume failure and the volume is able to be unloaded. This is normally a broken tape detected during midtape recovery, and is normally a high usage tape that has broken tape at the leader pin.	Quarantine the tape cartridge and contact your IBM Service Representative.	
14	Unrecoverable mechanical cartridge failure	0Eh	The drive has detected a mechanical cartridge failure and the cartridge is not able to be unloaded. Normally set when the tape is snapped/cut.	Do not attempt to extract the old tape cartridge. Call the tape drive supplier's help line.	Warning Event
15	Cartridge memory chip failure	0Fh	Set when a cartridge memory (CM) failure is detected on the loaded tape cartridge.	Replace the tape cartridge. If this error occurs on multiple cartridges, see Error Code 6 in “Single-character display (SCD)” on page 92.	Warning Event
16	Forced eject	10h	Set when you manually unload the tape cartridge while the drive was reading or writing.	No action is required. Informational message only.	Warning Event
17	Loaded media is Read-only format	11h	Set when a write attempt is made on a read-only cartridge. The flag is cleared when the cartridge is ejected (this flag is not supported for Ultrium 1 or Ultrium 2).	No action is required. Informational message only.	Warning Event
18	Tape directory is corrupted in the cartridge memory	12h	Set when the drive detects that the tape directory in the cartridge memory is corrupted.	Reread all data from the tape to rebuild the tape directory.	Warning Event
19	Nearing media life	13h	Set when the tape cartridge is nearing its specified end of life.	1. Copy the data to another tape cartridge. 2. Replace the tape cartridge.	Info Event
20	Clean now	14h	Set when the tape drive detects that it needs cleaning.	Clean the tape drive.	Warning Event

Flag Number	Flag Name	Hex Code	Description	Action Required	Event
21	Clean periodic	15h	Set when the drive detects that it needs routine cleaning.	Clean the tape drive as soon as possible. The drive can continue to operate, but you must clean the drive soon.	Warning Event
22	Expired clean	16h	Set when the tape drive detects an expired cleaning cartridge.	Replace the cleaning cartridge.	Warning Event
23	Invalid cleaning tape	17h	Set when the drive expects a cleaning cartridge and the loaded cartridge is not a cleaning cartridge.	Use a valid cleaning cartridge.	Warning Event
25	Interface	19h	Set when the tape drive detects a problem with the SCSI, Fibre Channel, or RS-422 interface.	Locate Error Code 8 or 9 in “Single-character display (SCD)” on page 92.	Warning Event
26	Cooling Fan Failure	1Ah	A tape drive cooling fan failed.	Fan failure inside tape drive mechanism or tape drive enclosure.	Warning Event
27	Power Supply	1Bh	A redundant power supply failed inside the tape drive enclosure. Check the enclosure users manual for instructions on replacing the failed power supply.	A redundant power supply failed inside the tape drive enclosure. Check the enclosure users manual for instructions on replacing the failed power supply.	Warning Event
30	Hardware A	1Eh	Set when a hardware failure occurs that requires that you reset the tape drive to recover.	A redundant power supply failed inside the tape drive enclosure. Check the enclosure users manual for instructions on replacing the failed power supply.	Warning Event
31	Hardware B	1Fh	Set when the tape drive fails its internal Power-On Self-Tests.	Note the error code on the single-character display and see in “Single-character display (SCD)” on page 92 for the appropriate instructions.	Warning Event
32	Interface	20h	Set when the tape drive detects a problem with the SCSI, Fibre Channel, or RS-422 interface.	Set when the tape drive detects a problem with the SCSI, Fibre Channel, or RS-422 interface.	Warning Event
33	Eject media	21h	Set when a failure occurs that requires you to unload the cartridge from the drive.	Unload the tape cartridge, then reinsert it and restart the operation.	Warning Event
34	Download fail	22h	Set when the tape drive detects a problem with the SCSI, Fibre Channel, or RS-422 interface.	Ensure that it is the correct FMR image. Download the FMR image again.	Warning Event
35	Drive humidity	23h	Sets when the drive humidity sensor indicates that the drive's humidity exceeds the recommended humidity of the drive.	See Error Code 1 in “Single-character display (SCD)” on page 92.	Warning Event

Flag Number	Flag Name	Hex Code	Description	Action Required	Event
36	Drive temperature	24h	Set when the drive's temperature sensor indicates that the drive's temperature is exceeding the recommended temperature of the library.	See Error Code 1 in “Single-character display (SCD)” on page 92.	Warning Event
37	Drive voltage	25h	Set when the drive detects that the externally supplied voltages are either approaching the specified voltage limits or are outside the voltage limits.	See Error Code 2 in “Single-character display (SCD)” on page 92.	Warning Event
38	Predictive failure	26h	A hardware failure of the tape drive is predicted. Call the tape drive supplier helpline.	Predictive failure of drive hardware	Warning Event
39	Diagnostics required	27h	A failure occurred that requires drive diagnostics to be run.	Use your backup software to rebuild the tape directory by reading all the data.	Warning Event
49	Diminished Native Capacity	31h	Set when Native Capacity is diminished.	No action is required. Informational message only.	Info Event
51	Tape directory invalid at unload	33h	Set when the tape directory on the tape cartridge that was previously unloaded is corrupted. The file-search performance is degraded.	Use your backup software to rebuild the tape directory by reading all the data.	Warning Event
52	Tape system area write failure	34h	Set when the tape cartridge that was previously unloaded cannot write its system area successfully.	Copy the data to another tape cartridge, and discard the old cartridge.	Warning Event
53	Tape system area read failure	35h	Set when the tape system area cannot be read successfully at load time.	Copy the data to another tape cartridge, and discard the old cartridge.	Warning Event
55	Load Failure	37h	The operation failed because the media cannot be loaded and threaded.	Remove the tape and try another. If the problem persists, contact your IBM® service representative. Ensure that tape drive firmware is at the latest version.	Warning Event
56	Unrecoverable unload failure	38h	The operation failed because the media cannot be unloaded.	Contact your IBM® service representative.	Warning Event
58	3Ah		A drive panic occurred.	Send drive dumps to your IBM Service Representative.	
59	WORM Medium – integrity check failed	3Bh	Set when the drive determines that the data on tape is suspect from a WORM point of view.	1. Copy the data to another WORM tape cartridge. 2. Discard the faulty WORM tape.	Warning Event

Flag Number	Flag Name	Hex Code	Description	Action Required	Event
60	WORM Medium – Overwrite attempted	3Ch	Set when the drive rejects a write operation because the rules for allowing WORM writes are not met. Data can be appended only to WORM media. Overwrites to WORM media are not allowed.	Write the data to a WORM tape cartridge or write the data to a non-WORM tape cartridge.	Warning Event
61	Encryption policy violation	3Dh	The drive is configured to require encryption, but encryption is not enabled.	Contact your IBM Service Representative.	

Sense data

When a drive encounters an error, it provides sense data as a response to the host.

Refer to the *IBM LTO Ultrium Tape Drive SCSI Reference* for tape drive sense data information.

In addition, you can use the IBM Tape Diagnostic Tool (ITDT) to further examine data and determine errors. See "IBM Tape Diagnostic tool (ITDT)" on page 40.

Reference

This section provides information about the Parts list, publications, and other reference documentation.

LTO media

LTO media is available in various types. Ensure you choose a media type that your drive supports.

IBM Ultrium media is available in the following types:

- Data cartridge
- WORM (Write Once, Read Many) cartridge
- Cleaning cartridge

To ensure that your IBM Ultrium tape drive conforms to IBM specifications for reliability, use only IBM LTO Ultrium tape cartridges. You can use other LTO-certified data cartridges, but they might not meet the standards of reliability that are established by IBM. The IBM LTO Ultrium data cartridge cannot be interchanged with the media used in other IBM non-LTO Ultrium tape products.

Figure 4 on page 56 shows the IBM LTO Ultrium data cartridge and its components.

1	LTO cartridge memory	4	Write-protect Switch
2	Cartridge door	5	Label area
3	Leader Pin	6	Insertion guide

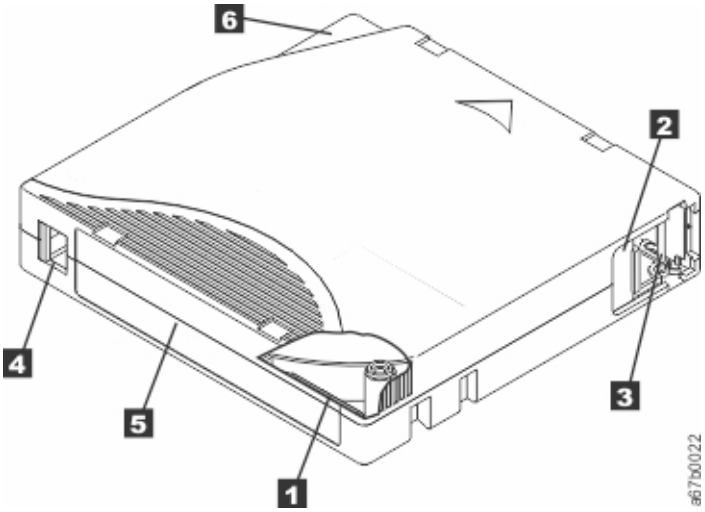

Figure 4. The IBM LTO Ultrium data cartridge

Data cartridges

The generations of IBM Ultrium data cartridges are identified by color.

Table 20. Cartridge types and colors

Type	**Color**
Ultrium 9	Teal
Ultrium 9 WORM	Teal and Silvery gray
Ultrium 8	Burgundy
Ultrium 8 WORM	Burgundy and Silvery gray
LTO M8	Purple
Ultrium 7	Purple
Ultrium 7 WORM	Purple and Silvery gray
Ultrium 6	Black
Ultrium 6 WORM	Black and Silvery gray
Ultrium 5	Burgundy
Ultrium 5 WORM	Burgundy and Silvery gray
Ultrium 4	Green
Ultrium 4 WORM	Green and Silvery gray
Ultrium 3	Slate Blue
Ultrium 3 WORM	Slate Blue and Silvery gray
Ultrium 2	Purple
Ultrium 1	Black

All generations contain 1/2-inch, dual-coat, magnetic tape.

You can order tape cartridges with the bar code labels included, or you can order custom labels. To obtain tape cartridges and bar code labels, see “Ordering media supplies” on page 73.

When tape is processed in the cartridges, Ultrium tape drives use a linear, serpentine recording format. The native data capacity and recording format of Ultrium data cartridges is as follows:

Table 21. Cartridge data capacity and recording formats

Type	Native Data Capacity	Recording Format
Ultrium 9	18 TB (45 TB at 2.5:1 compression)	Reads and writes data on 8960 tracks, 32 tracks at a time.
Ultrium 8	12 TB (30 TB at 2.5:1 compression)	Reads and writes data on 6656 tracks, 32 tracks at a time.
LTO M8	9 TB (22.5 TB at 2.5:1 compression)*	Reads and writes data on 3584 tracks, 32 tracks at a time.
Ultrium 7	6 TB (15 TB at 2.5:1 compression)	Reads and writes data on 3584 tracks, 32 tracks at a time.
Ultrium 6	2.5 TB (6.25 TB at 2.5:1 compression)	Reads and writes data on 2176 tracks, 16 tracks at a time.
Ultrium 5	1.5 TB (3 TB at 2:1 compression)	Reads and writes data on 1280 tracks, 16 tracks at a time.
Ultrium 4	800 GB (1.6 TB at 2:1 compression)	Reads and writes data on 896 tracks, 16 tracks at a time.
Ultrium 3	400 GB (800 GB at 2:1 compression)	Reads and writes data on 704 tracks, 16 tracks at a time.
Ultrium 2	200 GB (400 GB at 2:1 compression)	Reads and writes data on 512 tracks, 8 tracks at a time.
Ultrium 1	100 GB (200 GB at 2:1 compression)	Reads and writes data on 384 tracks, 8 tracks at a time.

*In any tape product with M8 cartridges, the minimum LTO8 tape drive firmware version is HB82.

The first set of tracks is written from near the beginning of the tape almost to the end of the tape. The head then repositions to the next set of tracks for the return pass. This process continues until all tracks are written and the cartridge is full, or until all data is written.

The cartridge door (2 in Figure 4 on page 56) protects the tape from contamination when the cartridge is out of the drive. The tape is attached to a leader pin (3 in Figure 4 on page 56) behind the door. When the cartridge is inserted into the drive, a threading mechanism pulls the pin (and tape) out of the cartridge, across the drive head, and onto a non-removable take-up reel. The head can then read or write data from or to the tape.

The write-protect switch (4 in Figure 4 on page 56) prevents data from being written to the tape cartridge. For more information, see “Write-Protect switch” on page 63.

The label area (5 in Figure 4 on page 56) provides a location to place a label. For more information, see “Bar code label” on page 61.

The insertion guide (6 in Figure 4 on page 56) is a large, notched area that prevents the cartridge from being inserted incorrectly.

Table 22. Nominal cartridge life: Load/unload cycles

Type	Load/Unload Cycles
Ultrium 9	100,000 (100k)
Ultrium 8	100,000 (100k)

Table 22. Nominal cartridge life: Load/unload cycles (continued)	
Type	**Load/Unload Cycles**
LTO M8	20,000 (20k)
Ultrium 7	20,000 (20k)
Ultrium 6	20,000 (20k)
Ultrium 5	20,000 (20k)
Ultrium 4	20,000 (20k)
Ultrium 3	20,000 (20k)
Ultrium 2	10,000 (10k)
Ultrium 1	5000 (5k)

Cartridge compatibility

The read/write capabilities of Ultrium data cartridges.

Table 23. Ultrium data cartridge compatibility with Ultrium tape drives

	IBM Ultrium Data Cartridges									
IBM Ultrium tape drive	**18 TB Ultrium 9**	**12 TB Ultrium 8**	**9 TB LTO M8**	**6 TB Ultrium 7**	**2.5 TB Ultrium 6**	**1.5 TB Ultrium 5**	**800 GB Ultrium 4**	**400 GB Ultrium 3**	**200 GB Ultrium 2**	**100 GB Ultrium 1**
Ultrium 9	Read/ Write	Read/ Write								
Ultrium 8		Read/ Write	Read/ Write	Read Only						
Ultrium 7				Read/ Write	Read/ Write					
Ultrium 6					Read/ Write	Read/ Write	Read Only			
Ultrium 5						Read/ Write	Read/ Write	Read Only		
Ultrium 4							Read/ Write	Read/ Write	Read Only	
Ultrium 3								Read/ Write	Read/ Write	Read Only
Ultrium 2									Read/ Write	Read/ Write
Ultrium 1										Read/ Write

LTO type M cartridge (M8)

Only new, unused LTO Ultrium 7 cartridges can be initialized as M8 cartridges. When a cartridge is initialized as M8, it cannot be changed back to L7. Initialized M8 cartridges can be written and read only in an LTO8 tape drive. LTO7 tape drives cannot read initialized M8 cartridges.

M8 cartridges can be purchased as either pre-initialized (also referred to as “labeled and initialized”) M8 data cartridges or uninitialized M8 data cartridges (M8 WORM cartridges are not supported). For either option, the bar code label is included. However, the uninitialized M8 data cartridge must first be initialized in tape libraries that support the automatic initialization of uninitialized M8 cartridges while under the control of ISV applications that recognize the “M8” bar code label.

A tape cartridge is initialized when it is first loaded into a compatible tape drive and data is written by the ISV application at the beginning of tape (sometimes referred to as "labeling a tape" or "writing from BOT"). The tape drive then establishes the density of the media.

If an uninitialized M8 cartridge is not initialized in a tape library that supports uninitialized M8 cartridges, then the cartridge might inadvertently and silently be initialized at the L7 density (that is, at a 6 TB native capacity) even if the bar code label states “M8”. This action might occur with the usage of a non LTO8 tape drive, a stand-alone LTO7 tape drive, a stand-alone LTO8 tape drive, earlier LTO8 tape drive firmware, or earlier ISV software that does not recognize that M8 cartridges must be mounted only in LTO8 tape drives. M8 cartridges that are inadvertently initialized at the L7 density can continue to be read and written in LTO7 and LTO8 tape drives. However, they remain limited to the 6 TB native capacity.

In any tape product with M8 cartridges, the minimum LTO8 tape drive firmware version is HB82.

Capacity Scaling

You can control the capacity of data cartridges to obtain faster seek times.

To control the capacity of the cartridge (for example, to obtain a faster seek time) issue the SCSI command **SET CAPACITY**. For information about this command, refer to the *IBM Ultrium Tape Drive SCSI Reference*.

WORM (Write Once, Read Many) cartridges

Certain records retention and data security applications require a Write Once, Read Many (WORM) method for storing data on tape.

The LTO Ultrium 4 and later drives enable WORM support when a WORM tape cartridge is loaded into the drive.

WORM media

The standard read/write media are incompatible with the WORM feature so a specially formatted WORM tape cartridge is required, see Figure 5 on page 59. Each WORM cartridge has a unique, worldwide cartridge identifier (WWCID), which comprises the unique CM chip serial number and the unique tape media serial number. For more information about how to choose and purchase the appropriate WORM tape cartridges for your tape drive, see “Ordering media supplies” on page 73.

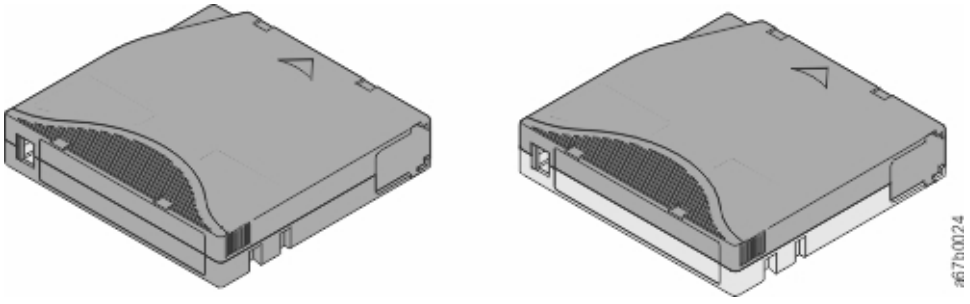

Figure 5. Ultrium Data and WORM Tape Cartridges

Data security on WORM media

Certain built-in security measures help ensure that the data that is written on a WORM cartridge does not become compromised.

For example:

- The format of an Ultrium WORM Tape Cartridge is not the same as the standard read/write media. This unique format prevents a drive that lacks WORM-capable firmware from writing on a WORM tape cartridge. For LTO 9, native data capacity is 18 TB and compressed data capacity is 45 TB.
- When the drive senses a WORM cartridge, the firmware prohibits the changing or altering of user data that is already written on the tape. The firmware notes the last point on the tape that can be appended.

WORM media errors

Several conditions can cause WORM media errors to occur.

- Information in the servo manufacturer's word (SMW) on the tape must match information from the cartridge memory (CM) module in the cartridge. If it does not match, a media Error Code 7 posts on the drive's single-character display (SCD).
- Inserting a WORM tape cartridge into a drive that is not compatible with WORM causes the cartridge to be treated as an unsupported medium. The drive reports a media Error Code 7. Upgrading the drive firmware to the correct code level resolves the problem.

WORM requirements

You can add WORM capability to your IBM Ultrium tape drive.

To add WORM capability to your IBM LTO Ultrium 9 drives, you must use IBM Ultrium 9 WORM tape cartridges (18 TB), or IBM Ultrium 8 tape cartridges (12 TB). See “Ordering media supplies” on page 73.

Cleaning cartridge

A specially labeled IBM LTO Ultrium Cleaning Cartridge is used to clean the drive head.

The drive itself determines when a head must be cleaned. It alerts you when the single-character display (SCD) flashes a C. To clean the head manually, insert a cleaning cartridge into the tape load compartment. See Figure 29 on page 92. The drive completes the cleaning automatically. When the cleaning is finished, the drive ejects the cartridge, and the SCD is blank.

Note: The drive automatically ejects an expired cleaning cartridge without running the cleaning process. Replace the expired cleaning cartridge with a new cleaning cartridge and insert it into the drive.

The IBM cleaning cartridges are valid for 50 uses. The cartridge's LTO-CM chip tracks the number of times that the cartridge is used.

Important: After 50 uses, the cleaning cartridge expires. It is no longer usable, and must be replaced

Cartridge memory chip (LTO-CM)

All generations of the IBM LTO Ultrium Data Cartridges include a Linear Tape-Open Cartridge Memory (LTO-CM) chip.

The Linear Tape-Open Cartridge Memory (LTO-CM) chip (1 in Figure 4 on page 56) holds information about that specific cartridge, the media in the cartridge and the data on the media. The LTO-CM enhances the efficiency of the cartridge. For example, the LTO-CM stores the end-of-data location. When the cartridge is inserted and the **Write** command is entered, the drive can quickly locate the recording area and begin recording. The LTO-CM also aids in determining the reliability of the cartridge by storing data about its age, how many times it was loaded, and how many errors it accumulated. When you unload a tape cartridge, the tape drive writes any pertinent information to the cartridge memory.

The storage capacity of the Generation 9 LTO-CM is 32640 bytes. This capacity is double that of Generations 6, 7, and 8 LTO-CM (16320 bytes), and four times the capacity of Generations 5 and 4 LTO-CM, which is 8160 bytes. LTO Generations 1, 2, and 3 have an LTO-CM capacity of 4096 bytes.

Bar code label

Data cartridges can have bar code labels for identification..

A bar code label contains:

- A volume serial number (VOLSER) that is human-readable.
- A bar code that the library can read.

Note: LTO tape drives do not require tape cartridges to have bar code labels. However, IBM libraries require tape cartridges to have bar code labeled on them for automation and human readability.

Table 24. Bar code label requirements for Ultrium tape drives and libraries

Ultrium Tape Drive/Library	Bar Code Label Requirements
3573	Required
3576	Required
3580	Not required
3581	Required with optional Bar Code Reader
3582	Required
3583	Required
3584	Required

When read by a library's bar code reader, the bar code identifies the cartridge's VOLSER to the library. The bar code also tells the library whether the cartridge is a data cartridge or cleaning cartridge. In addition, the bar code includes the two-character media-type identifier, see Table 25 on page 61.

Figure 6 on page 62 shows a sample bar code label for the LTO Ultrium Tape Cartridge.

Tape cartridges are ordered with the labels included or with custom labels. To order tape cartridges and bar code labels, see “Ordering media supplies” on page 73. The bar code for usage in IBM tape libraries must meet predefined specifications. They include (but are not limited to):

- Eight uppercase alphanumeric characters, where the last 2 characters refer to the cartridge generation and WORM capability. See Table 25 on page 61.
- Label and printing to be non-glossy.
- Nominal narrow line or space width of 0.423 mm (0.017 in.)
- Wide to narrow ratio of 2.75:1.
- Minimum bar length of 11.1 mm (0.44 in.)

Table 25. Cartridges and VOLSERs compatible with the LTO tape drives

Cartridges	VOLSER
Ultrium 9 Data Cartridge	xxxxxxL9
Ultrium 9 WORM Cartridge	xxxxxxLZ
Ultrium 8 Data Cartridge	xxxxxxL8
Ultrium 8 WORM Cartridge	xxxxxxLY
LTO M8 Cartridge	xxxxxxM8
Ultrium 7 Data Cartridge	xxxxxxL7
Ultrium 7 WORM Cartridge	xxxxxxLX
Ultrium 6 Data Cartridge	xxxxxxL6

Table 25. Cartridges and VOLSERs compatible with the LTO tape drives (continued)	
Cartridges	**VOLSER**
Ultrium 6 WORM Cartridge	xxxxxxLW
Ultrium 5 Data Cartridge	xxxxxxL5
Ultrium 5 WORM Cartridge	xxxxxxLV
Ultrium 4 Data Cartridge	xxxxxxL4
Ultrium 4 WORM Cartridge	xxxxxxLU
Ultrium 3 Data Cartridge	xxxxxxL3
Ultrium 3 WORM Cartridge	xxxxxxLT
Ultrium 2 Data Cartridge	xxxxxxL2
Ultrium 1 Data Cartridge (READ ONLY)	xxxxxxL1
LTO Ultrium Cleaning Cartridge	CLNxxxLx
*An Ultrium 3 Tape Drive must have a minimum firmware level of 54xx for it to be compatible with the WORM cartridge.	

To determine the complete specifications of the bar code and the bar code label, visit the web at http://www.ibm.com/ and enter "IBM LTO Ultrium Cartridge Label Specification" in the search box. Or contact your IBM sales representative.

When a bar code label is attached to a tape cartridge, place the label only in the recessed label area (see 5 in "LTO media" on page 55). A label that extends outside of the recessed area can cause loading problems in the drive.

Attention: Do not place any type of mark on the white space at either end of the bar code. A mark in this area might prevent the library from reading the label.

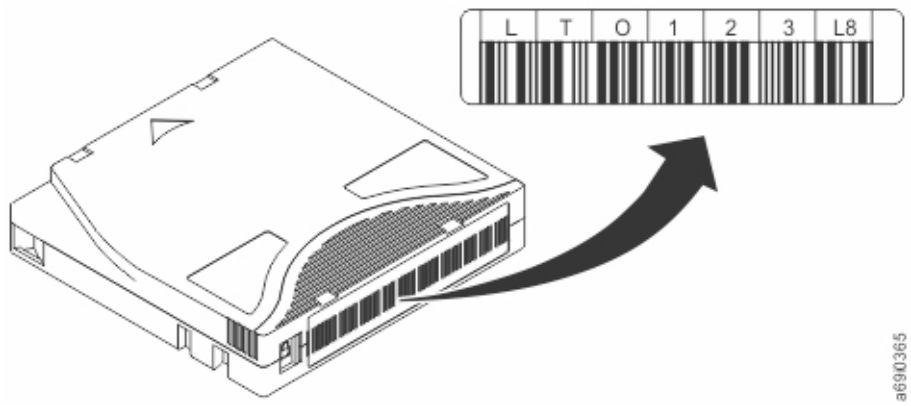

Figure 6. Sample bar code label on the LTO Ultrium Tape Cartridge

Guidelines for bar code labels

Apply some basic guidelines when you use bar code labels for your data cartridges.

- Use only IBM-approved bar code labels on cartridges to be used in an IBM tape library.
- Do not reuse a label or reapply a used label over an existing label.
- Before you apply a new label, remove the old label by slowly pulling it at a right angle to the cartridge case.

- Use peel-clean labels that do not leave a residue after it is removed. If there is glue residue on the cartridge, remove it by gently rubbing it with your finger. Do not use a sharp object, water, or a chemical to clean the label area.
- Examine the label before it is applied to the cartridge. Do not use the label if it has voids or smears in the printed characters or bar code. A library 's inventory operation takes much longer if the bar code label is not readable.
- Remove the label from the label sheet carefully. Do not stretch the label or cause the edges to curl.
- Position the label within the recessed label area (see 5 in Figure 4 on page 56).
- With light finger pressure, smooth the label so that no wrinkles or bubbles exist on its surface.
- Verify that the label is smooth and parallel, and has no roll-up or roll-over. The label must be flat to within 0.5 mm (0.02 in.) over the length of the label and have no folds, missing pieces, or smudges.
- Do not place other machine-readable labels on other surfaces of the cartridge. They might interfere with the ability of the drive to load the cartridge.

Write-Protect switch

The position of the write-protect switch on the tape cartridge determines whether you can write to the tape.

If the switch (1) is set to:

- The locked position (solid red). Data cannot be written to the tape.
- The unlocked position (black void). Data can be written to the tape.

If possible, use your server's application software to write-protect your cartridges (rather than manually setting the write-protect switch). This setting allows the server's software to identify a cartridge that no longer contains current data and is eligible to become a scratch (blank) data cartridge. Do not write-protect scratch (blank) cartridges; the tape drive is not able to write new data to them.

If you must manually set the write-protect switch, slide it left or right to the wanted position.

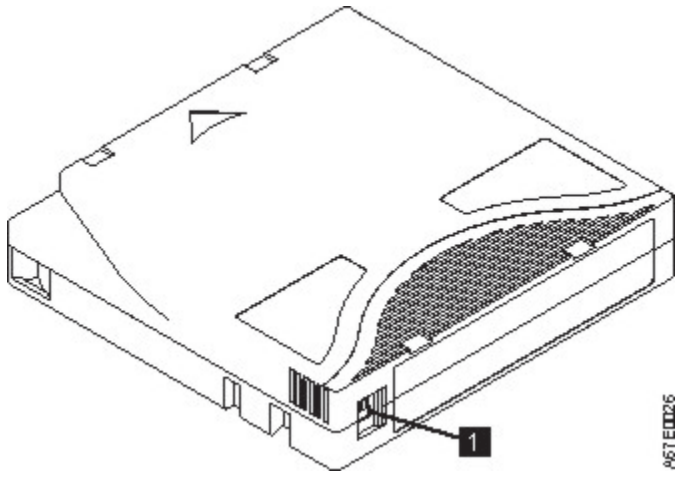

Figure 7. Setting the write-protect switch

Table 26. Location of the write-protect switch

1	Write-protect switch

Handling the cartridges

Incorrect handling or an incorrect environment can damage cartridges or their magnetic tape.

Attention: Do not insert a damaged tape cartridge into the drive. A damaged cartridge can interfere with the reliability of a drive and might void the warranties of the drive and the cartridge.

Before a tape cartridge is inserted, inspect the cartridge case, cartridge door, and write-protect switch for breaks.

To avoid damage to your tape cartridges and to ensure the continued high reliability of your IBM LTO Ultrium tape drives, use the following guidelines:

Providing training

Providing training to the users of your tape drive can prolong the life of your tape cartridges.

- Post procedures that describe appropriate media handling in places where people gather.
- Ensure that anyone who handles tape is properly trained in handling and shipping procedures. This training includes operators, users, programmers, archival services, and shipping personnel.
- Ensure that any service or contract personnel who complete archiving procedures are properly trained in media-handling procedures.
- Include media-handling procedures as part of any services contract.
- Define and make personnel aware of data recovery procedures.

Ensuring proper packaging

When you ship or store data cartridges, ensure that they are packed securely.

About this task

- When a cartridge is shipped, use the original or better packaging.
- Always ship or store a cartridge in a jewel case.
- Use only a recommended shipping container that securely holds the cartridge in its jewel case during transportation. Ultrium Turtlecases (by Perm-A-Store) are tested and found to be satisfactory (see Figure 8 on page 64). They are available at http://www.turtlecase.com.

Figure 8. Tape cartridges in a Turtlecase

- Never ship a cartridge in a commercial shipping envelope. Always place it in a box or package.
- If you ship the cartridge in a cardboard box or a box of a sturdy material, ensure that you
  - Place the cartridge in polyethylene plastic wrap or bags to protect it from dust, moisture, and other contaminants.
  - Pack the cartridge snugly; do not allow it to move around.

– Double-box the cartridge (place it inside a box, then place that box inside the shipping box) and add padding between the two boxes (see Figure 9 on page 65).

Figure 9. Double-boxing tape cartridges for shipping

Proper acclimation and environmental conditions

Acclimate a tape cartridge to the operating environment before you use it.

About this task

- Before you use a tape cartridge, acclimate it to the operating environment for 24 hours or the time necessary to prevent condensation in the drive. The time varies, depending on the environmental extremes to which the cartridge was exposed.
- Ensure that all surfaces of a cartridge are dry before it is inserted.
- Do not expose the cartridge to moisture or direct sunlight.
- Do not expose recorded or blank cartridges to stray magnetic fields of greater than 100 oersteds (for example, terminals, motors, video equipment, X-ray equipment, or fields that exist near high-current cables or power supplies). Such exposure causes the loss of recorded data or makes the blank cartridge unusable.
- Maintain the conditions that are described in “Environmental and shipping specifications for tape cartridges” on page 72.

Completing a thorough inspection

Complete a thorough inspection of your tape cartridge before you use it.

About this task

After a cartridge is purchased and before it is used, complete the following steps:

- Inspect the cartridge 's packaging to determine potential rough handling.
- When a cartridge is inspected, open only the cartridge door. Do not open any other part of the cartridge case. The upper and lower parts of the case are held together with screws; separating them destroys the usefulness of the cartridge.
- Inspect the cartridge for damage before it is used or stored.
- Inspect the rear of the cartridge (the part that loads first into the tape load compartment) and ensure that there are no gaps in the seam of the cartridge case (see **1** in Figure 10 on page 66 and **4** in Figure 12 on page 68). If there are gaps in the seam (see Figure 10 on page 66), the leader pin might be dislodged. Go to “Repositioning or reattaching a leader pin” on page 67.

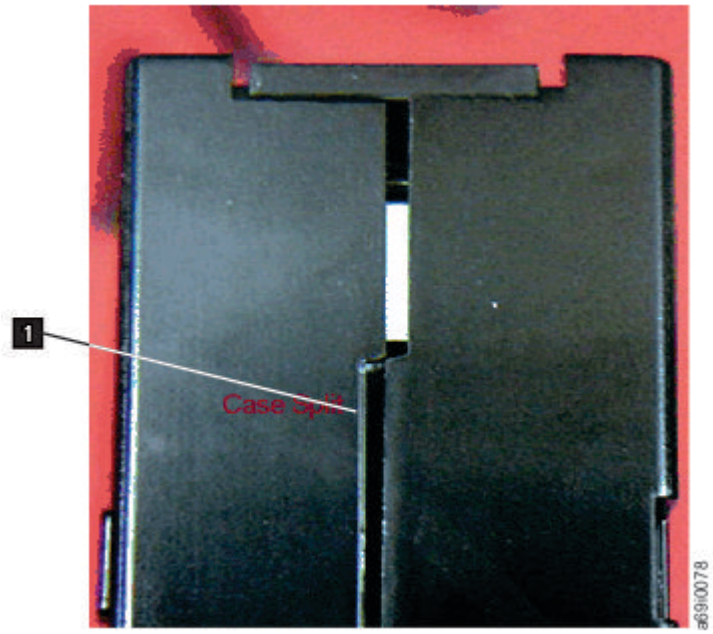

Figure 10. Checking for gaps in the seams of a cartridge

- Check that the leader pin is properly seated (see 2 in Figure 11 on page 68).
- If you suspect that the cartridge was mishandled but it appears usable, copy any data onto a good cartridge immediately for possible data recovery. Discard the mishandled cartridge.
- Review handling and shipping procedures.

Handling the cartridge carefully

Handle tape cartridges carefully.

About this task

- Do not drop the cartridge. If the cartridge drops, slide the cartridge door back and ensure that the leader pin is properly seated in the pin-retaining spring clips. See 2 in Figure 11 on page 68. If the leader pin becomes dislodged, go to “Repositioning or reattaching a leader pin” on page 67.
- Do not handle tape that is outside the cartridge. Handling the tape can damage the tape 's surface or edges, which might interfere with read or write reliability. Pulling on tape that is outside the cartridge can damage the tape and the brake mechanism in the cartridge.
- Do not stack more than six cartridges.
- Do not degauss a cartridge that you intend to reuse. Degaussing makes the tape unusable.

Examples of cartridge problems

Several examples of cartridge problems.

About this task

Split cartridge case. See Figure 10 on page 66.

The cartridge's case is damaged. There is a high possibility of media damage and potential loss.

Procedure

1. Look for cartridge mishandling.

2. Use the IBM Leader Pin Reattachment Kit (part number 08L9129) to correctly seat the pin (see “Repositioning or reattaching a leader pin” on page 67). Then, immediately use data recovery procedures to minimize chances of data loss.
3. Review media-handling procedures.

Results

Improper placement of leader pin. See Figure 11 on page 68.

The leader pin is misaligned.

1. Look for cartridge damage.
2. Use the IBM Leader Pin Reattachment Kit (part number 08L9129) to correctly seat the pin (see “Repositioning or reattaching a leader pin” on page 67). Then, immediately use data recovery procedures to minimize chances of data loss.

Repositioning or reattaching a leader pin

Procedures involved with repositioning or reattaching a leader pin in your cartridge.

Attention: Use a repaired tape cartridge only to recover data and move it to another cartridge. Continued use of a repaired cartridge might void the warranties of the drive and the cartridge.

If the leader pin in your cartridge becomes dislodged from its pin-retaining spring clips or detaches from the tape, you must use the IBM Leader Pin Reattachment Kit (part number 08L9129) to reposition or reattach it. (Do not reattach the pin if you must remove more than 7 meters (23 feet) of leader tape.) The sections that follow describe each procedure.

Repositioning a leader pin

Procedure for repositioning a leader pin.

About this task

A leader pin that is improperly seated inside a cartridge interferes with the operation of the drive. Figure 11 on page 68 shows a leader pin in the incorrect 1 and correct 2 positions.

To place the leader pin in its proper position, you need the following tools:

- Plastic or blunt-end tweezers
- Cartridge manual rewind tool (from Leader Pin Reattachment Kit, part number 08L9129)

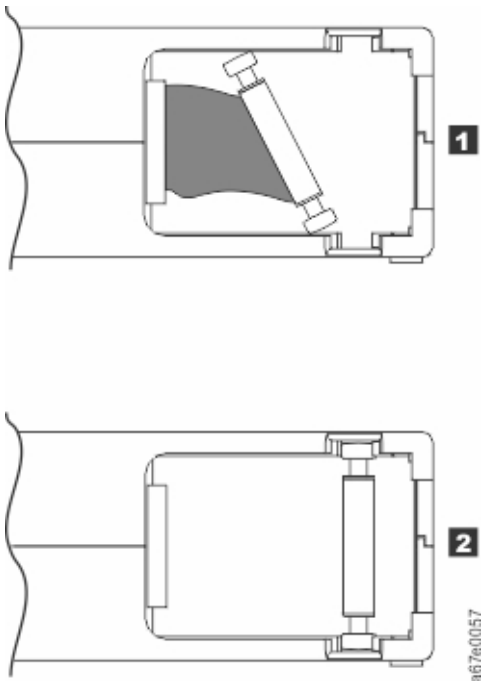

Figure 11. Leader pin in the incorrect and correct positions

To reposition the leader pin:

Procedure

1. Slide open the cartridge door (1 in Figure 12 on page 68) and locate the leader pin 2 (you might need to shake the cartridge gently to roll the pin toward the door).
2. With plastic or blunt-end tweezers, grasp the leader pin and position it in the pin-retaining spring clips 3.
3. Press the leader pin gently into the clips until it snaps into place and is firmly seated.
4. Close the cartridge door.

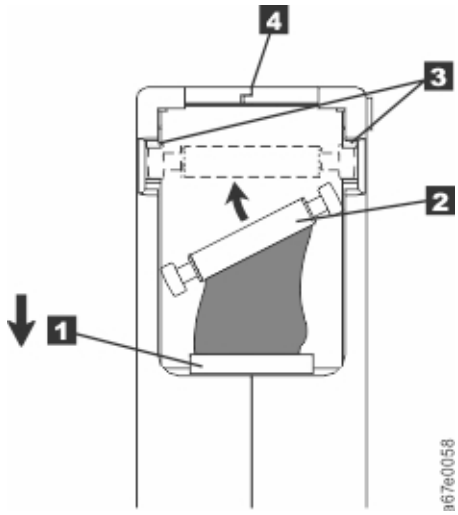

Figure 12. Placing the dislodged leader pin into the correct position

5. To rewind the tape, insert the cartridge manual rewind tool (1 in Figure 13 on page 69) into the cartridge 's hub 2 and turn it clockwise until the tape becomes taut.

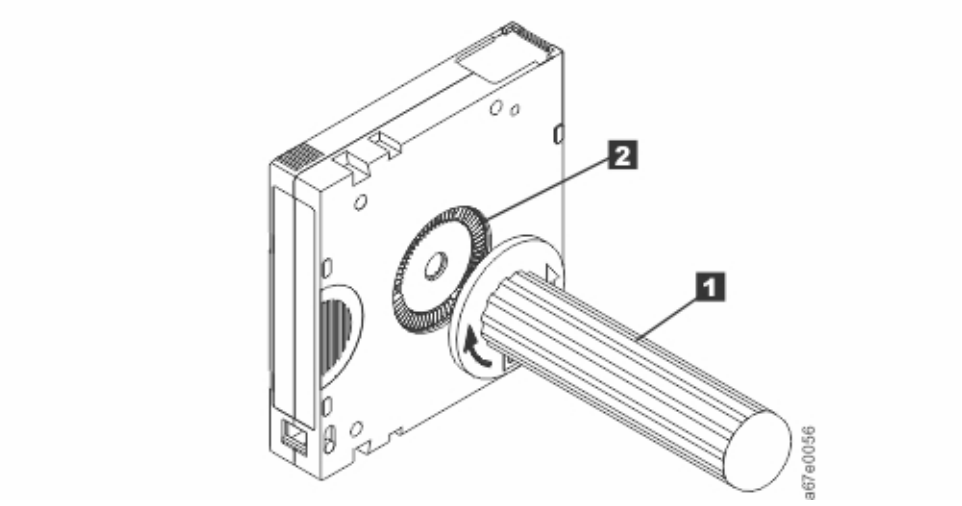

Figure 13. Rewinding the tape into the cartridge

6. Remove the rewind tool by pulling it away from the cartridge.
7. If you suspect that the cartridge was mishandled but it appears usable, copy any data onto a good cartridge immediately for possible data recovery. Discard the mishandled cartridge.

Reattaching a leader pin

Procedure for reattaching a leader pin.

About this task

The first meter of tape in a cartridge is leader tape. When the leader tape is removed there is a possibility of tape breakage. After the leader pin is reattached, transfer data from the defective tape cartridge. **Do not reuse the defective tape cartridge**.

The Leader Pin Reattachment Kit contains three parts:

- **Leader pin attach tool** (See 1 in Figure 14 on page 70). A plastic brace that holds the cartridge door open.
- **Cartridge manual rewind tool** (See 2 in Figure 14 on page 70). A device that fits into the cartridge's hub and enables you to wind the tape into and out of the cartridge.
- **Pin supplies** (See 3 in Figure 14 on page 70). Leader pins and C-clips.

Attention:

- Use only the IBM Leader Pin Reattachment Kit to reattach the leader pin to the tape. Other methods of reattaching the pin damages the tape, the drive, or both.
- Use this procedure on your tape cartridge only when the leader pin detaches from the magnetic tape and you must copy the cartridge's data onto another cartridge. Destroy the damaged cartridge after you copy the data. This procedure might affect the performance of the leader pin during threading and unloading operations.
- Touch only the end of the tape. Touching the tape in an area other than the end can damage the tape's surface or edges, which might interfere with read or write reliability.

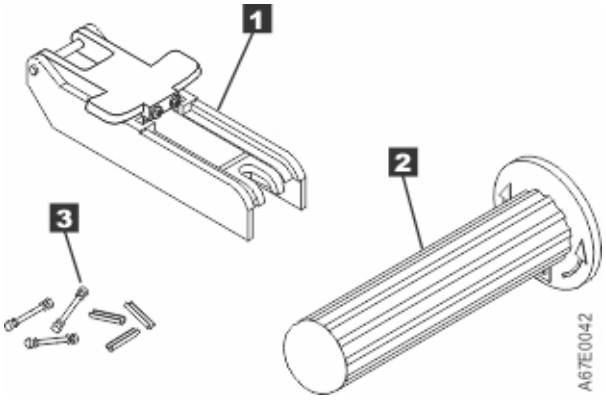

Figure 14. Leader pin reattachment kit

This procedure describes how to reattach a leader pin.

To reattach a leader pin with the IBM leader pin reattachment kit:

1. Attach the leader pin attach tool (1 in Figure 15 on page 70) to the cartridge 2 so that the tool's hook 3 latches into the cartridge's door 4. Pull the tool back to hold the door open, then slide the tool onto the cartridge. Open the tool's pivot arm 5.

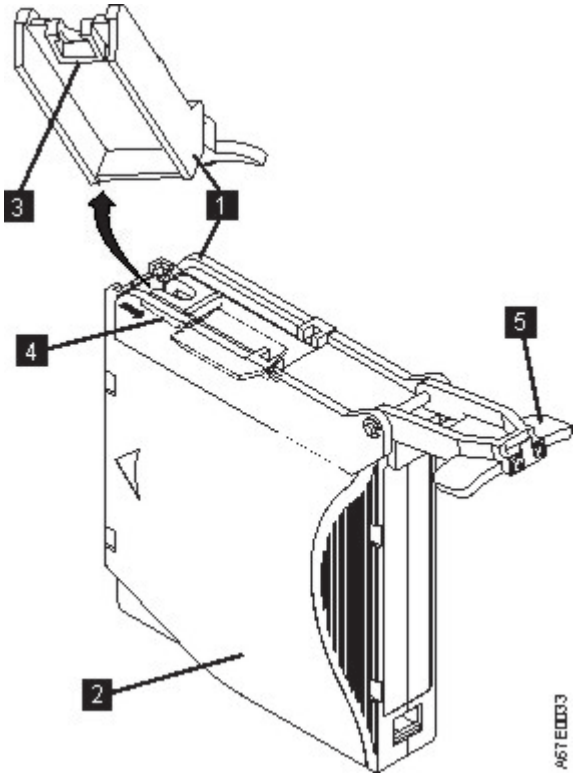

Figure 15. Attaching the leader pin attach tool to the cartridge

2. To find the end of the tape inside the cartridge, attach the cartridge manual rewind tool (1 in Figure 16 on page 71) to the cartridge's hub 2 by fitting the tool 's teeth between the teeth of the hub. Turn the tool clockwise until you see the end of the tape inside the cartridge. Then, slowly turn the rewind tool counterclockwise to bring the tape edge toward the cartridge door 3.
3. Continue to turn the rewind tool counterclockwise until approximately 13 cm (5 in.) of tape hangs from the cartridge door. If necessary, grasp the tape and pull gently to unwind it from the cartridge.
4. Remove the rewind tool by pulling it away from the cartridge. Set the tool and the cartridge aside.

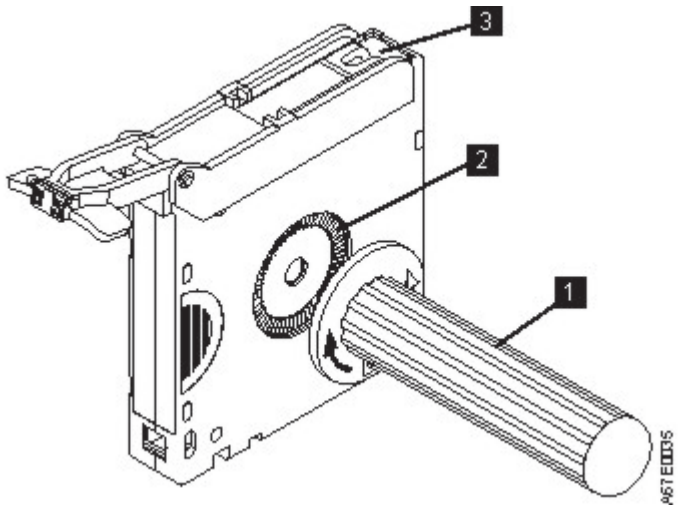

Figure 16. Winding the tape out of the cartridge

5. On the leader pin (1 in Figure 17 on page 71), locate the open side of the C-clip 2. The C-clip is a small black part that secures the tape 3 to the pin.
6. Remove the C-clip from the leader pin by using your fingers to push the clip away from the pin. Set the pin aside and discard the clip.

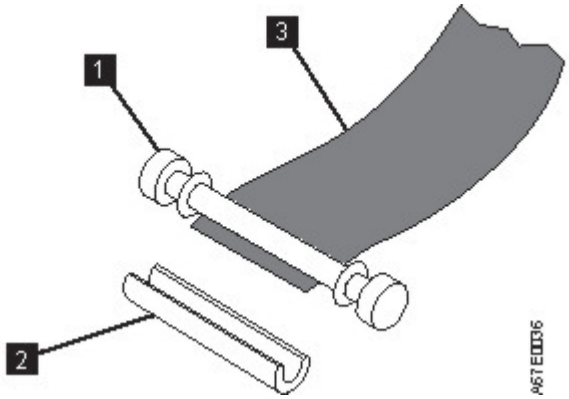

Figure 17. Removing the C-clip from the leader pin

7. Position the tape in the alignment groove of the leader pin attach tool (see 1 in Figure 18 on page 72).
8. Place a new C-clip into the retention groove 2 (Figure 18 on page 72) on the leader pin attachment tool and make sure that the clip's open side faces up.
9. Place the leader pin (from step "6" on page 71) into the cavity 3 (Figure 18 on page 72) of the leader pin attach tool.

Attention: To prevent the leader pin from rolling into the cartridge, in the following step use care when the tape is folded over the pin.

10. Fold the tape over the leader pin and hold it with your fingers (see Figure 18 on page 72).

    Note: Use care to ensure that the tape is centered over the leader pin. Failure to properly center the tape on the pin causes the repaired cartridge to fail. When the tape is properly centered, a 0.25 mm (0.01-in.) gap exists on both sides of the pin.

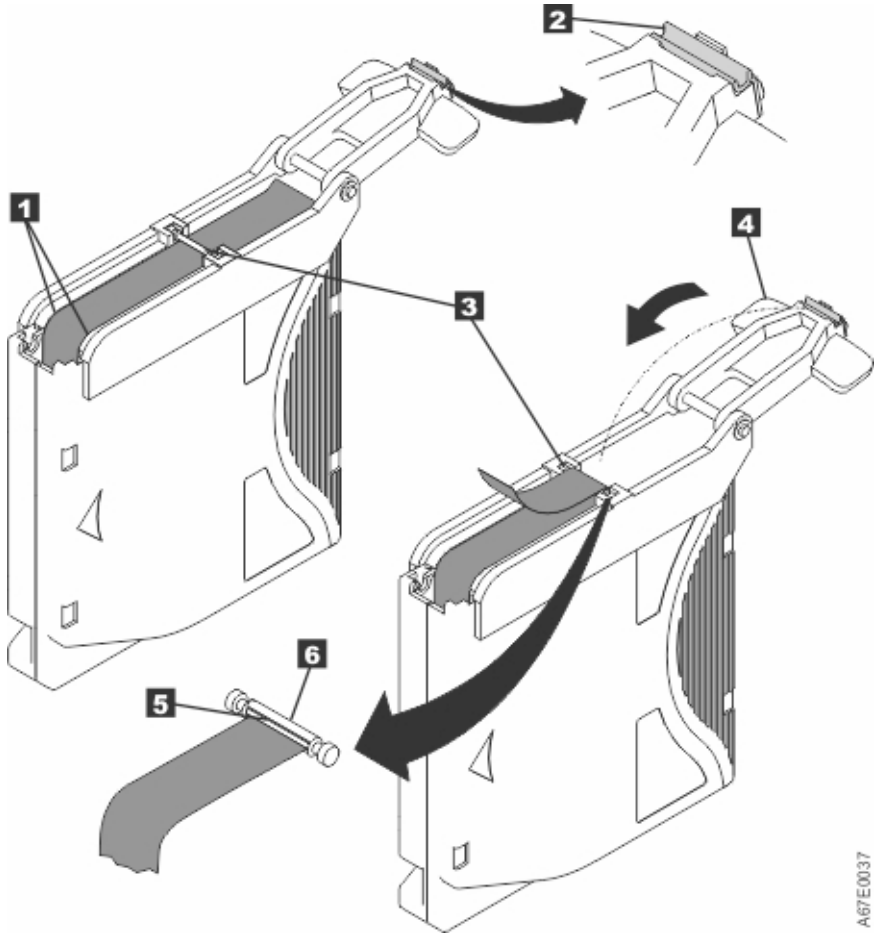

Figure 18. Attaching the leader pin to the tape

11. Close the pivot arm 4 of the leader pin attach tool by swinging it over the leader pin so that the C-clip snaps onto the pin and the tape.
12. Swing the pivot arm open and trim the excess tape 5 so that it is flush with the reattached leader pin 6.
13. Use your fingers to remove the leader pin from the cavity 3 in the leader pin attach tool.
14. Use the cartridge manual rewind tool to wind the tape back into the cartridge (wind the tape clockwise). Ensure that the leader pin is latched by the pin-retaining spring clips on each end of the leader pin.
15. Remove the rewind tool.
16. Remove the leader pin attach tool by lifting its end away from the cartridge.

Environmental and shipping specifications for tape cartridges

Specifications for tape cartridges: acclimation, environmental, storage.

Before you use a tape cartridge, acclimate it to the operating environment for 24 hours or the time necessary to prevent condensation in the drive. The time varies, depending on the environmental extremes to which the cartridge was exposed.

The best storage container for the cartridges (until they are opened) is the original shipping container. The plastic wrapping prevents dirt from accumulating on the cartridges and partially protects them from humidity changes.

When you ship a cartridge, place it in its jewel case or in a sealed, moisture-proof bag to protect it from moisture, contaminants, and physical damage. Ship the cartridge in a shipping container that has enough packing material to cushion the cartridge and prevent it from moving within the container.

Table 27 on page 73 gives the environment for operating, storing, and shipping LTO Ultrium Tape Cartridges.

Table 27. Tape Cartridge Temperature and Humidity Specifications

Mode	Temperature[1]	Relative Humidity (non-condensing)	Dew Point Temperature
Recommended Environment	16°C - 25°C	20% - 50%	22°C
Allowable Environment	16°C - 32°C	20% - 80%	22°C
Local permanent tape damage temperature [2]	>52°C	N/A	N/A
Shipping	25°C - 49°C	5% - 80%	26°C

Notes:

1. Per the U932 LTO Tape Format Specification, this mode is known as Short Term Storage Temperature and the temperature range is 16°C to 35°C.
2. Local tape temperature in excess of 52°C might cause permanent tape damage.

Disposing of tape cartridges

Current rules about the appropriate disposal of tape cartridges.

Under the current rules of the US Environmental Protection Agency (EPA), regulation 40CFR261, the LTO Ultrium Tape Cartridge is classified as non-hazardous waste. As such, it might be disposed of in the same way as normal office trash. These regulations are amended from time to time, and you must review them at the time of disposal.

If your local, state, country (non-US), or regional regulations are more restrictive than EPA 40CFR261, you must review them before you dispose of a cartridge. Contact your account representative for information about the materials that are in the cartridge.

If a tape cartridge must be disposed of in a secure manner, you can erase the data on the cartridge with a high-energy ac degausser (use a minimum of 4000 oersted peak field over the entire space that the cartridge occupies). The tape must make two passes through the field at 90 degree orientation change for each pass to achieve complete erasure. Some commercial degaussers have two magnetic field regions offset 90 degrees from each other to accomplish complete erasure in one pass for higher throughput. Degaussing makes the cartridge unusable.

If you burn the cartridge and tape, ensure that the incineration complies with all applicable regulations.

Ordering media supplies

Information about ordering several generations of media supplies for your tape drive.

About this task

Table 28 on page 74 lists the cartridges and media supplies that you can order for the drive.

Table 28. Media supplies

Supply Item	Methods of Ordering Specify the VOLSER characters that you want.
20-PACK IBM LTO Ultrium 9 18 TB Data Cartridge (with attached labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 553. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
20-PACK IBM LTO Ultrium 9 18 TB Data Cartridge (without labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 653. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
5-PACK IBM LTO Ultrium 9 18 TB Data Cartridge (black and white labels unattached)	Order as part number xxxxxxx through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
20-PACK IBM Ultrium 9 18 TB WORM Tape Cartridge (with attached labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 573. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
20-PACK IBM Ultrium 9 18 TB WORM Tape Cartridge (without labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 673. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
20-PACK IBM LTO Ultrium 8 12 TB Data Cartridge (with attached labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 552. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
20-PACK IBM LTO Ultrium 8 12 TB Data Cartridge (without labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 652. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
5-PACK IBM LTO Ultrium 8 12 TB Data Cartridge (black and white labels unattached)	Order as part number 01PL340 through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto

Table 28. Media supplies (continued)

Supply Item	Methods of Ordering Specify the VOLSER characters that you want.
20-PACK IBM Ultrium 8 12 TB WORM Tape Cartridge (with attached labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 572. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
20-PACK IBM Ultrium 8 12 TB WORM Tape Cartridge (without labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 672. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
20-PACK IBM Type M (M8) 9 TB Data Cartridge	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 452. Specify the VOLSER characters that you want. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto.
20-PACK IBM LTO Ultrium 7 6 TB Data Cartridge (with attached labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 551. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
20-PACK IBM LTO Ultrium 7 6 TB Data Cartridge (without labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 651. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
5-PACK IBM LTO Ultrium 7 6 TB Data Cartridge (black and white labels unattached)	Order as part number 38L7189 through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
20-PACK IBM Ultrium 7 6 TB WORM Tape Cartridge (with attached labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 571. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
20-PACK IBM Ultrium 7 6 TB WORM Tape Cartridge (without labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 671. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto

Table 28. Media supplies (continued)

Supply Item	Methods of Ordering Specify the VOLSER characters that you want.
20-PACK IBM LTO Ultrium 6 2.5 TB Data Cartridge (with attached labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 550. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
20-PACK IBM LTO Ultrium 6 2.5 TB Data Cartridge (without labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 650. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
5-PACK IBM LTO Ultrium 6 2.5 TB Data Cartridge (black and white labels unattached)	Order as part number 35P1902 through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
20-PACK IBM Ultrium 6 2.5 TB WORM Tape Cartridge (with attached labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 570. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
20-PACK IBM Ultrium 6 2.5 TB WORM Tape Cartridge (without labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 670. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
20-PACK IBM LTO Ultrium 5 1.5 TB Data Cartridge (with attached labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 014. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
20-PACK IBM LTO Ultrium 5 1.5 TB Data Cartridge (without labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 015. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
5-PACK IBM LTO Ultrium 5 1.5 TB Data Cartridge (black and white labels unattached)	Order as part number 46C2084 through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto

Table 28. Media supplies (continued)

Supply Item	Methods of Ordering Specify the VOLSER characters that you want.
20-PACK IBM Ultrium 5 1.5 TB WORM Tape Cartridge (with attached labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 034. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
20-PACK IBM Ultrium 5 1.5 TB WORM Tape Cartridge (without labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 035. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
20-PACK IBM LTO Ultrium 4 800 GB Data Cartridge (with attached labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 010. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
20-PACK IBM LTO Ultrium 4 800 GB Data Cartridge (without labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 011. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
5-PACK IBM LTO Ultrium 4 800 GB Data Cartridge (black and white labels unattached)	Order as part number 95P4278 through an IBM-authorized distributor.
20-PACK IBM Ultrium 4 800 GB WORM Tape Cartridge (with attached labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 032. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
20-PACK IBM Ultrium 4 800 GB WORM Tape Cartridge (without labels)	Order the cartridge from your IBM Sales Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 033. You can also order through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
IBM LTO Ultrium 3 400 GB Data Cartridge Order VOLSER labels separately (see “Ordering bar code labels” on page 78).	Order as part number 24R1922 through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
IBM LTO Ultrium 3 400 GB WORM Tape Cartridge Order VOLSER labels separately (see “Ordering bar code labels” on page 78).	Order as part number 96P1203 through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto

Table 28. Media supplies (continued)	
Supply Item	**Methods of Ordering** **Specify the VOLSER characters that you want.**
IBM LTO Ultrium 2 200 GB Data Cartridge Order VOLSER labels separately (see "Ordering bar code labels" on page 78).	Order as part number 08L9870 through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
IBM LTO Ultrium 1 100 GB Data Cartridge Order VOLSER labels separately (see "Ordering bar code labels" on page 78).	Order as part number 08L9120 through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
IBM LTO Ultrium Cleaning Cartridge (universal cleaning cartridge for use with Ultrium drives) VOLSER labels are included.	Order as part number 35L2086 through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
Leader Pin Reattachment Kit	Order as part number 08L9129 through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto
Manual Rewind Tool	Order as part number 08L9130 through an IBM-authorized distributor, or online at: http://www-1.ibm.com/storage/tape/lto

To find the closest IBM-authorized distributor, visit the web at http://www.ibm.com/storage/media) or call 1-888-IBM-MEDIA.

Ordering bar code labels

If you want to order bar code labels for your tape cartridges, you can order them from several authorized suppliers.

About this task

The LTO Ultrium tape drives do not require cartridge bar code labels. However, if you use your data cartridges or cleaning cartridges in an IBM tape library product, you might need cartridge bar code labels if your tape library product requires them. See Table 24 on page 61. You can order these labels separately from the IBM data cartridges and cleaning cartridges.

You can order bar code labels directly from the authorized label suppliers in Table 29 on page 78.

Table 29. Authorized suppliers of custom bar code labels	
In America	**In Europe and Asia**
EDP/Colorflex Broomfield, CO U. S. A. Telephone: 800-438-8362 http://www.tri-optic.com	EDP Europe, Ltd. U. K. Telephone: 44 (0) 1245-322380 http://www.edpeurope.com/media-label
Dataware Houston, TX 77274 U. S. A. Telephone: 800-426-4844 http://www.datawarelabels.com/	Dataware Labels Europe Australia Telephone: (029) 496-1111 http://www.datawarelabels.com/

Table 29. Authorized suppliers of custom bar code labels (continued)	
In America	**In Europe and Asia**
NetC Trumbell, CT U. S. A. Telephone: 203-372-6382 http://www.netcllc.com/	NetC Europe Ltd U. K. Telephone: 44 (0) 1823 49 1439 http://www.netclabels.co.uk
	NetC Asia Pacific Pty Ltd Australia Telephone: 61 (0) 7 5442 6263 http://www.netclabels.com.au

Manually removing a tape cartridge

This Procedure is to be performed by IBM service personnel only. The purpose of this section is to assist you in determining the condition of the cartridge or the magnetic tape and to direct you to the procedure you must follow to remove the cartridge.

Attention

- It is strongly recommended that the drive and stuck tape be returned to IBM for removal and recovery.
- If the cartridge in the drive is an INPUT tape containing ACTIVE or 'ONLY COPY' data (i.e., there is no backup), eject commands issued at the host fail to unload the tape, and power-cycling the drive fails to eject the cartridge, make no further attempts to unload this tape. Call Technical Support and open a PMR if one isn't already open, to initiate the process of sending the drive with the loaded cartridge in for recovery.
- These procedures must be performed only by a trained IBM service provider. SSRs should claim their time against service code 33 ECA 013 when performing this procedure.
- Inform the customer the following procedure has high risk of damaging the drive and high risk of not being able to recover the data.
- The best solution for recovering data on a damaged cartridge is to send it to IBM for professional data recovery.
- Before this procedure is used, you must exhaust all other means of removing the tape cartridge from the drive. Use this procedure only if you cannot remove the tape cartridge with any other means.
- Determine from the customer if the cartridge contains critical customer data. If the cartridge contains sensitive data that cannot leave the site, inform the customer that certain failure conditions diagnostic tests are done to test the drive for continued use.
- The following removal procedures can destroy customer data! Use extreme care when handling or removing the customer’s tape cartridges to minimize tape damage and lost data.
- DO NOT TOUCH the magnetic tape or tape path. Both are sensitive to the oil and salt from your skin. Use clean, lint-free gloves when working around magnetic tape or the tape path components.
- Electrostatic-sensitive components: Consider using an ESD Kit.
- After you remove the tape cartridge, advise the customer to copy the data to another cartridge and to remove this tape cartridge from service.
- Do not use power tools or magnetic tools to complete this procedure.
- To avoid contamination and electrostatic-discharge damage to the drive, never touch the head or electronic components inside the drive.
- If you cannot remove the cartridge from the drive with the following procedures, contact your next level of support.

- The cartridge does not eject automatically at the end of a mid-tape recovery. Instead, the tape is reloaded into the drive and might result in the loss of data.
- INTERNAL COMPONENTS OF THE DRIVE ARE DELICATE AND CAN EASILY BE DAMAGED. EXERCISE EXTREME CAUTION WHEN MANUALLY REMOVING A CARTRIDGE THAT WILL NOT EJECT AFTER PRESSING **UNLOAD**.

Before you begin

1. Attempt to remove the cartridge with the device power ON and with library manager, a host application, or **Unload**. Press and hold **Unload** for 12 seconds. This procedure causes the drive to eject the cartridge when it completed the mid-tape recovery.
2. Attempt to remove the cartridge by power-cycling the drive. Look for the drive to attempt a mid-tape recovery.

   Note: It can take up to 15 minutes for the cartridge to rewind and unload.
3. If the cartridge unloads, inform the operator that the cartridge is unloaded. If the cartridge does not unload, repeat steps 2 and 3 again before you continue with this procedure.

Recommended tools

- #1 Phillips screwdriver
- ESD kit
- Flashlight (optional)
- #1 Flathead screwdriver (optional)

Beginning procedure

1. Refer to the enclosure documentation for instructions on removing the drive.
2. Place the drive on a non-slip, sturdy work surface.
3. Ground yourself to the drive with the ESD kit.
4. Remove the cover of the drive:
   a. To remove the drive bezel, pull the right side of the bezel from the front of the drive, then pull the left side of the bezel out of the frame of the drive.
   b. Remove the cover of the internal drive:
      i) Remove the four cover-mounting screws (1 in Figure 19 on page 80). Two screws are on each side of the drive.
      ii) Remove the cover by lifting it up.

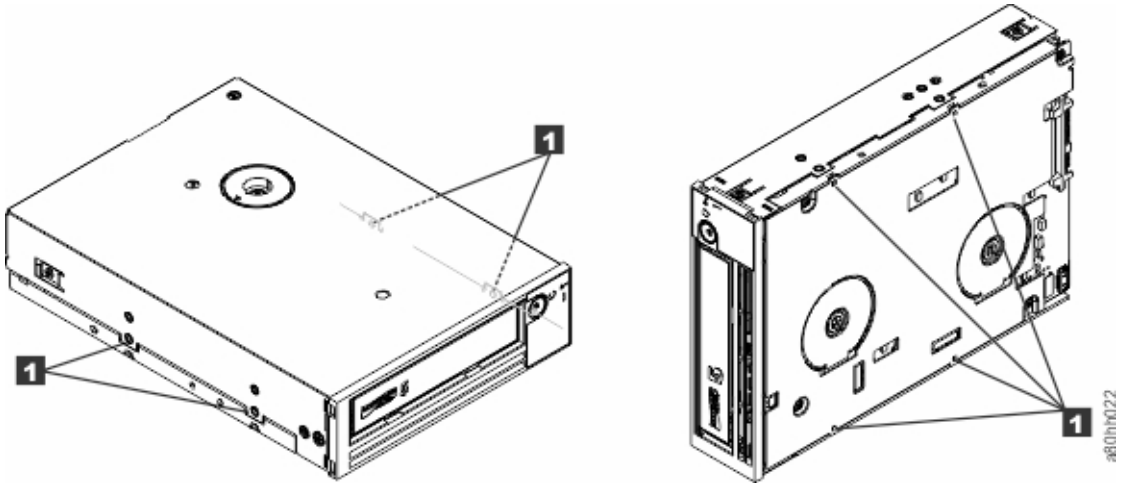

Figure 19. Removing the bezel and the cover from the internal drive

5. Inspect the drive to decide which of the following conditions most closely match the symptom on the drive:
   - **Tape spooled off the supply reel** - All the tape appears to be on the takeup reel and no tape is on the supply reel (inside the cartridge). Test the drive after the procedure is completed.
   - **Tape pulled from leader pin (or broken at the front end)** - All the tape appears to be on the supply reel (inside the cartridge) and little or no tape appears to be on the takeup reel. The leader block is positioned in the takeup reel. Return the drive after the procedure is completed.
   - **Tape broken in mid-tape** - Tape appears to be on both the supply reel (inside the cartridge) and takeup reel. Test the drive after the procedure is completed.
   - **Tape tangled along tape path** - Tape appears to be tangled and damaged but intact. Return the drive after the procedure is completed.

     -- OR --

     No damage to tape (or no apparent failure) - There appears to be no damage or slack to the tape. Return the drive after the procedure is completed.

Tape spooled off supply reel

Attention: DO NOT TOUCH THE OUTER GUIDE RAIL (2 in Figure 20 on page 82). THIS RAIL IS VERY DELICATE AND EASILY DAMAGED.

1. From the takeup reel, pull an arm 's length of tape around the rear of the tape path and over the head and rollers on the left side of the drive.
2. Set the drive on its left side with the head and tape path facing up.
3. Make sure that the tape is not twisted. Untwist tape if required.
4. Moisten a cotton swab with water and wet approximately 13 mm (0.5 in.) of the tape end and feed it onto the supply reel (inside the cartridge).
5. Turn the supply reel (4 in Figure 20 on page 82) clockwise, allowing the moistened tape to adhere to the hub as it winds around the supply reel (inside the cartridge).

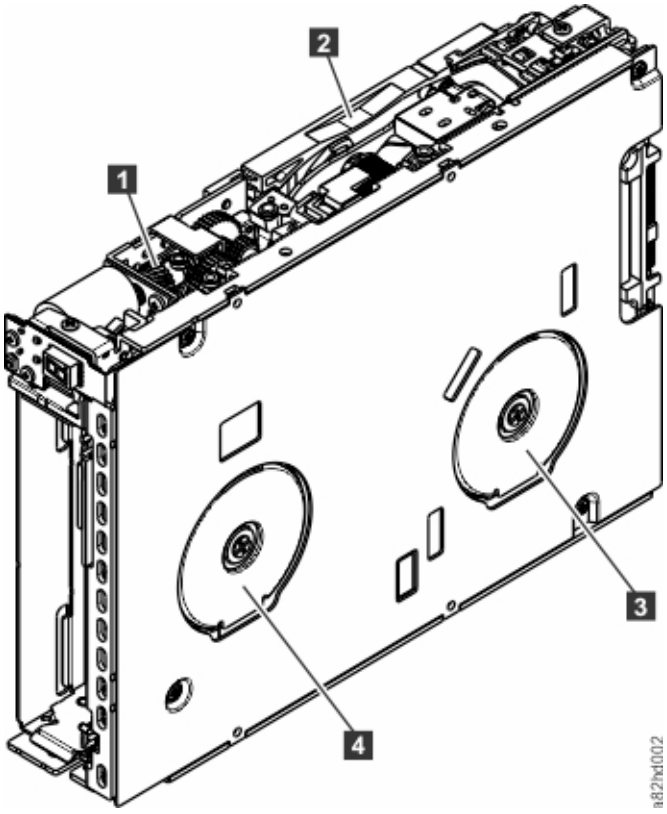

Figure 20. Rewinding tape into cartridge

1	Loader motor worm gear	3	Takeup reel motor
2	Outer guide rail WARNING: DO NOT TOUCH	4	Supply reel motor

6. Continue spooling into the cartridge until the tape is taut and remains within the flanges of the tape guiding rollers. Turn the supply reel (4 in Figure 20 on page 82) 10 more turns. Ensure that you do not stretch the tape.
7. Reassemble the drive, reversing the steps in "Beginning procedure" on page 80.
8. Reassemble the drive chassis, following the steps in "Replacing the internal drive" on page 90.
9. Reinstall the drive canister into the cradle assembly. Ensure that the connector on the drive is seated properly into the connector on the cradle.
10. Allow the drive to complete mid-tape recovery. This action takes several minutes. When this activity completes, push **Unload** to eject the cartridge.
11. Test the drive (see "Function code 1: Run drive diagnostics" on page 20) to determine if it needs to be replaced.

Tape pulled from or broken near leader pin

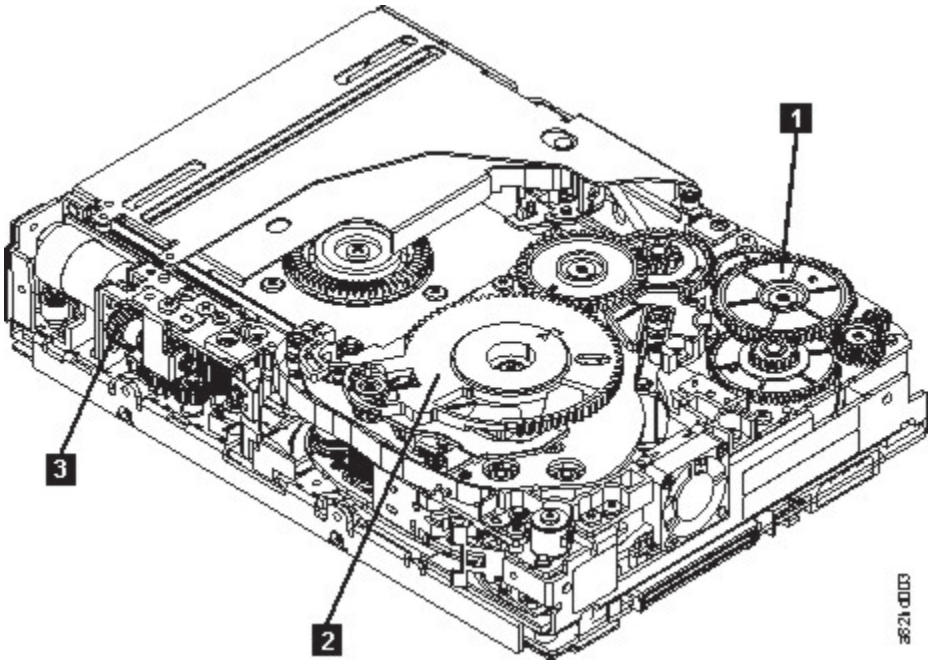

Figure 21. Drive with cover removed to reveal gear train.

1	Threader intermediate gear	2	Threader mechanism gear	3	Loader motor worm gear

1. Pull out tape from the takeup reel.

   Note: If there is more than approximately 0.6 m (2 ft.) of tape on the takeup reel, go to "Tape broken in mid-tape" on page 84.
2. If there is less than approximately 0.6 m (2 ft.) of tape on the takeup reel, cut off the excess tape as close to the leader pin as possible.
3. Reattach the leader pin to the remaining tape. For instructions, see "Repositioning or reattaching a leader pin" on page 67.
4. Locate the threader intermediate gear (1 in Figure 21 on page 83) near the rear of the drive. You can use your finger to rotate the threader intermediate gear (1 in Figure 21 on page 83) and slowly rotate the threader mechanism gear (2 in Figure 21 on page 83) clockwise.

   This draws the tape leader block assembly (LBA) into the cartridge.
5. As the leader pin is secured in the cartridge, you hear the leader pin retention spring clips click into place. If you do not hear the click, continue rolling until the threader intermediate gear (1 in Figure 21 on page 83) stops. The LBA is in the correct position.

   Note: Be sure to keep tension on the tape as the LBA is drawn into the cartridge.
6. Rotate the loader motor worm gear (3 in Figure 21 on page 83) clockwise as viewed from the front of the drive until it stops. This action releases the LBA leader pin.
7. Rotate the threader intermediate gear (1 in Figure 21 on page 83) counterclockwise until the leader block is in front of the read/write head. This action moves the LBA out of the cartridge.

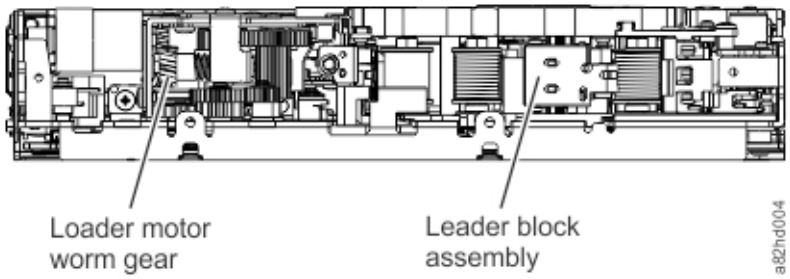

Figure 22. Leader block assembly (LBA)

1 Loader motor worm gear 2 Leader block assembly (LBA)

8. Rotate the loader motor worm gear (3 in Figure 21 on page 83) counterclockwise as viewed from the front of the drive until it stops.
9. Remove the cartridge from the cartridge loader tray.
10. Reassemble the drive by reversing the procedure in Step 4 in "Beginning procedure" on page 80.
11. Reassemble the drive chassis.
12. Refer to the appropriate procedure to install the new drive and return the failed drive.

Tape broken in mid-tape

1. With the front of the drive facing you, pull an arm 's length of tape out of the takeup reel. From the takeup reel, thread tape around the rear of the tape path and over the head rollers on the left side of the drive.

   Note: If there is less than approximately 5 cm (2 in.) of tape on the takeup reel, go to "Tape pulled from or broken near leader pin" on page 83.
2. From the supply reel inside the cartridge, pull approximately 0.3 m (1 ft.) of tape.
3. Make sure that the tape is not twisted. Untwist tape if required.
4. Moisten a cotton swab with water, and wet approximately 13 mm (0.5 in.) of the tape end. Overlap the tape ends, loosely mending them together.
5. Set the drive on its left side with the head and tape path facing up.
6. Turn the supply reel (4 in Figure 23 on page 85) clockwise, carefully guiding the mended portion of the tape to wind around the hub of the supply reel that is located inside the cartridge. Continue spooling into the cartridge until the tape is taut. The tape must remain within the flanges of the tape guiding rollers. Turn the supply reel (4 in Figure 23 on page 85) 10 more turns. Ensure that you do not stretch the tape.

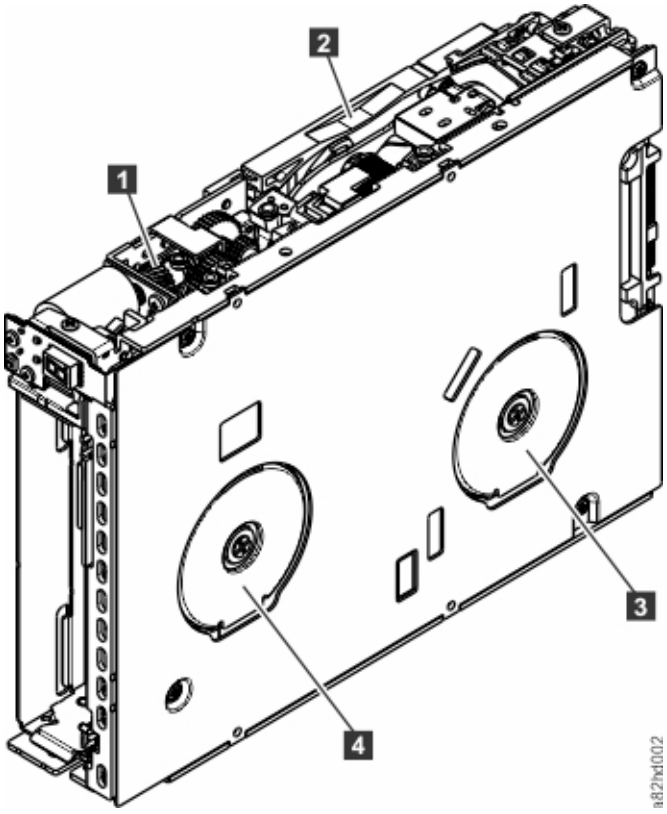

Figure 23. Rewinding tape into cartridge

1	Loader motor worm gear	3	Takeup reel motor
2	Outer guide rail WARNING: DO NOT TOUCH	4	Supply reel motor

7. Reassemble the drive by reversing the procedure in Step 4 in “Beginning procedure” on page 80.
8. Reassemble the chassis by following the steps in “Replacing the internal drive” on page 90.
9. Allow the drive to complete mid-tape recovery. This action takes several minutes. When this activity completes, push **Unload** to eject the cartridge.
10. Test the drive (see “Function code 1: Run drive diagnostics” on page 20) to determine whether it needs to be replaced.

Tape tangled along tape path

1. Carefully pull out excess tape and untangle.

   Note: If you find the tape to be broken, try one of these procedures:

   - “Tape spooled off supply reel” on page 81
   - “Tape pulled from or broken near leader pin” on page 83
   - “Tape broken in mid-tape” on page 84
2. Set the drive on its left side with the head and tape path facing up.

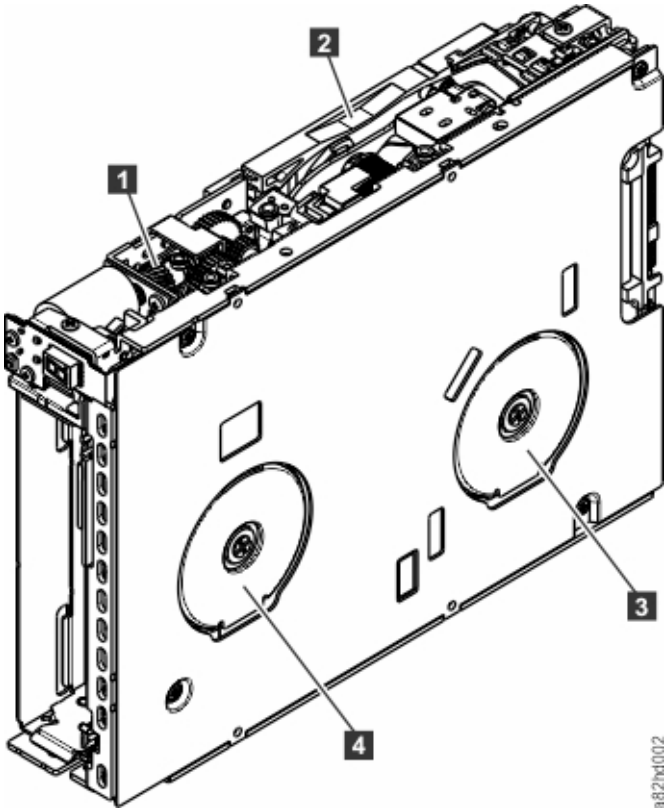

Figure 24. Rewinding tape into cartridge

1	Loader motor worm gear	3	Takeup reel motor
2	Outer guide rail WARNING: DO NOT TOUCH	4	Supply reel motor

3. Turn the supply reel (4 in Figure 24 on page 86) clockwise.
4. Continue spooling into the cartridge until the tape is taut and remains within the flanges of the tape guiding rollers. Turn the supply reel (4 in Figure 24 on page 86) 10 turns. Ensure that you do not stretch the tape.
5. Reassemble the chassis by following the steps in "Replacing the internal drive" on page 90.
6. Allow the drive to complete mid-tape recovery. This action takes several minutes. When this activity completes, push **Unload** to eject the cartridge.
7. Test the drive (see "Function code 1: Run drive diagnostics" on page 20) to determine whether it needs to be replaced.

No apparent failure or damage to tape

1. Set the drive on its left side with the head and tape path facing up.

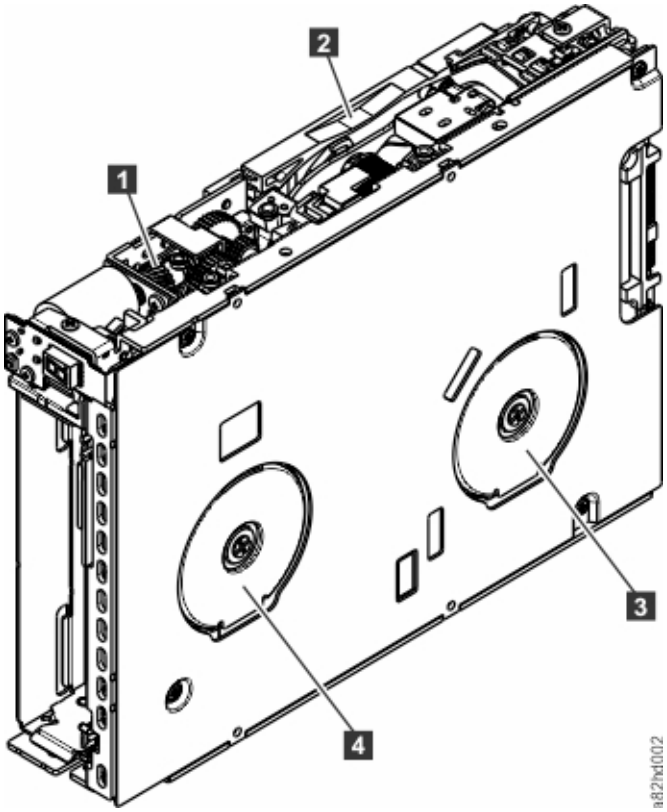

Figure 25. Rewinding tape into cartridge

1	Loader motor worm gear	3	Takeup reel motor
2	Outer guide rail WARNING: DO NOT TOUCH	4	Supply reel motor

2. Begin spooling the tape back into the cartridge by turning the supply reel motor (4 in Figure 25 on page 87) clockwise.
3. Continue spooling into the cartridge until the tape is taut and remains within the flanges of the tape guiding rollers. Ensure that you do not stretch the tape. Continue spooling until all tape is removed from the takeup reel (3 in Figure 25 on page 87).
4. Locate the threader intermediate gear (1 in Figure 26 on page 88) near the rear of the drive. You can use your finger to rotate the threader intermediate gear (1 in Figure 26 on page 88) and slowly rotate the threader mechanism gear (2 in Figure 26 on page 88) clockwise.

   This action draws the tape leader block assembly (LBA) into the cartridge.

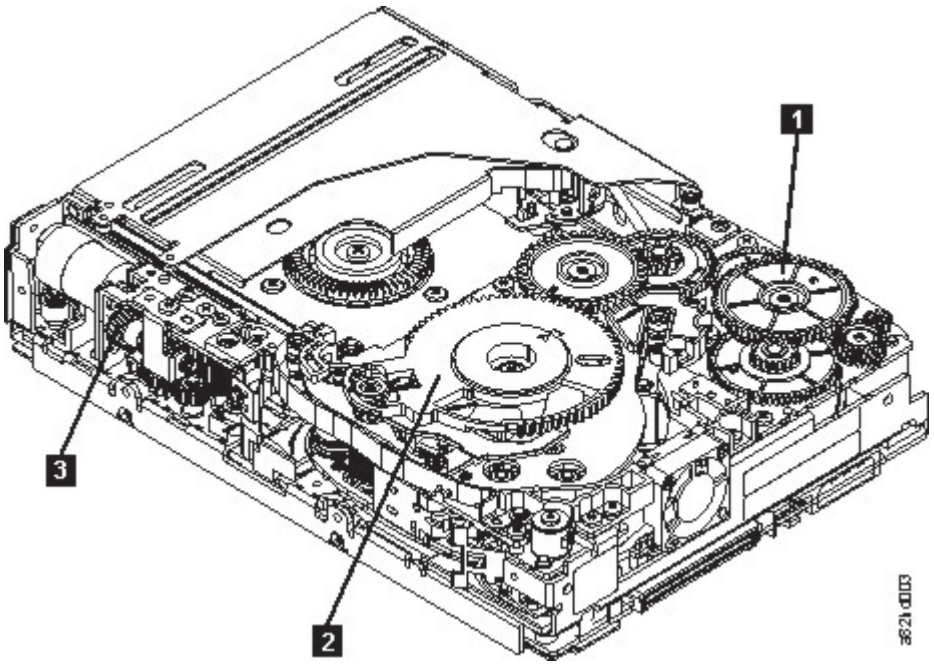

Figure 26. Drive with cover removed to reveal gear train.

1	Threader intermediate gear	2	Threader mechanism gear	3	Loader motor worm gear

5. As the leader pin is secured in the cartridge, you hear the leader pin retention spring clips click into place. If you do not hear the click, continue rolling until the threader intermediate gear (1 in Figure 26 on page 88) stops. The LBA is in the correct position.

   Note: Be sure to keep tension on the tape as the LBA is drawn into the cartridge.
6. Rotate the loader intermediate gear (1 in Figure 27 on page 88) clockwise as viewed from the front of the drive until it stops. This action releases the LBA leader pin.
7. Rotate the threader motor worm gear (3 in Figure 27 on page 88) counterclockwise until the leader block is in front of the read/write head. This action moves the LBA out of the cartridge.

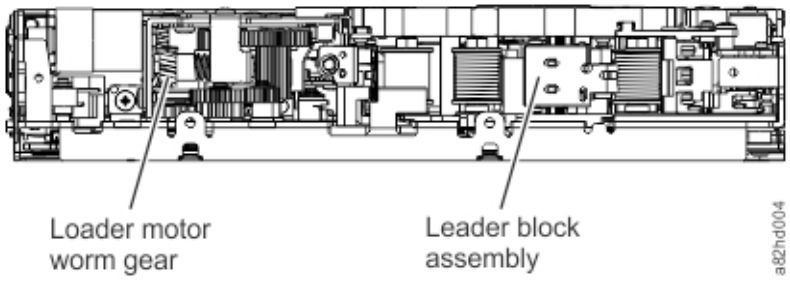

Figure 27. Leader block assembly (LBA)

1	Loader motor worm gear	2	Leader block assembly (LBA)

8. Rotate the loader motor worm gear (3 in Figure 27 on page 88) counterclockwise as viewed from the front of the drive until it stops.
9. Remove the cartridge from the cartridge loader tray.
10. Reassemble the drive by reversing the procedure in Step 4 in “Beginning procedure” on page 80.
11. Reassemble the drive chassis by following the steps in “Replacing the internal drive” on page 90.
12. Refer to the appropriate procedure to install the new drive and return the failed drive.

Cleaning the drive head

Use an IBM Ultrium cleaning cartridge to clean the tape drive head.

About this task

Attention: When the drive head is cleaned, use the IBM LTO Ultrium cleaning cartridge. You might use another LTO cleaning cartridge, but it might not meet the standards of reliability that is established by IBM.

Clean the drive head whenever C displays on the Single-character Display (SCD) and the **Fault** light is flashing once per second. It is not recommended that you clean the drive head on a periodic basis; only when the drive requests to be cleaned.

Note: In Maintenance mode, a flashing C with the **Fault** light On, means to insert a cartridge, not to clean the drive head.

To clean the head, insert the cleaning cartridge into the tape load compartment. The drive completes the cleaning automatically in less than 3 minutes, then ejects the cartridge. The drive completes a short load/unload test while the cartridge is ejected. Wait for the drive to finish before the cartridge is removed.

Note: The drive automatically ejects an expired cleaning cartridge.

The IBM LTO Ultrium Cleaning Cartridge is valid for 50 uses, and then must be replaced.

Accessibility

Accessibility features help a user who has a physical disability, such as restricted mobility or limited vision, to use the HTML version of the customer documentation successfully.

Features

The major accessibility features for the HTML version of this document are:

- You can use screen-reader software and a digital speech synthesizer to hear what is displayed on the screen. The following screen readers are tested: WebKing and Window-Eyes.
- You can operate all features with the keyboard instead of the mouse.

Navigating by keyboard

You can use keys or key combinations to complete operations and initiate many menu actions that are also done through mouse actions. You can navigate the HTML version of the *IBM TS4300 Tape Library User's Guide* help system from the keyboard with the following key combinations:

- To traverse to the next link, button, or topic, press **Tab** inside a frame (page).
- To move to the previous topic, press ^ or Shift+Tab.
- To scroll all the way up or down, press **Home** or **End**.
- To print the current page or active frame, press Ctrl+P.
- To select, press **Enter**.

Accessing the publications

You can view the publications for this library in Adobe Portable Document Format (PDF) with the Adobe Acrobat Reader. The PDFs are provided at the following website: http://www.ibm.com/storage/support/ .

Replacing the internal drive

This Procedure is to be performed by IBM service personnel only. Several steps are involved with the internal drive replacement procedure.

Bar code label

Data cartridges can have bar code labels for identification..

A bar code label contains:

- A volume serial number (VOLSER) that is human-readable.
- A bar code that the library can read.

Note: LTO tape drives do not require tape cartridges to have bar code labels. However, IBM libraries require tape cartridges to have bar code labeled on them for automation and human readability.

Table 30. Bar code label requirements for Ultrium tape drives and libraries

Ultrium Tape Drive/Library	Bar Code Label Requirements
3573	Required
3576	Required
3580	Not required
3581	Required with optional Bar Code Reader
3582	Required
3583	Required
3584	Required

When read by a library's bar code reader, the bar code identifies the cartridge's VOLSER to the library. The bar code also tells the library whether the cartridge is a data cartridge or cleaning cartridge. In addition, the bar code includes the two-character media-type identifier, see Table 31 on page 90.

Figure 28 on page 91 shows a sample bar code label for the LTO Ultrium Tape Cartridge.

Tape cartridges are ordered with the labels included or with custom labels. To order tape cartridges and bar code labels, see “Ordering media supplies” on page 73. The bar code for usage in IBM tape libraries must meet predefined specifications. They include (but are not limited to):

- Eight uppercase alphanumeric characters, where the last 2 characters refer to the cartridge generation and WORM capability. See Table 31 on page 90.
- Label and printing to be non-glossy.
- Nominal narrow line or space width of 0.423 mm (0.017 in.)
- Wide to narrow ratio of 2.75:1.
- Minimum bar length of 11.1 mm (0.44 in.)

Table 31. Cartridges and VOLSERs compatible with the LTO tape drives

Cartridges	VOLSER
Ultrium 9 Data Cartridge	xxxxxxL9
Ultrium 9 WORM Cartridge	xxxxxxLZ
Ultrium 8 Data Cartridge	xxxxxxL8
Ultrium 8 WORM Cartridge	xxxxxxLY

Table 31. Cartridges and VOLSERs compatible with the LTO tape drives (continued)	
Cartridges	**VOLSER**
LTO M8 Cartridge	xxxxxxM8
Ultrium 7 Data Cartridge	xxxxxxL7
Ultrium 7 WORM Cartridge	xxxxxxLX
Ultrium 6 Data Cartridge	xxxxxxL6
Ultrium 6 WORM Cartridge	xxxxxxLW
Ultrium 5 Data Cartridge	xxxxxxL5
Ultrium 5 WORM Cartridge	xxxxxxLV
Ultrium 4 Data Cartridge	xxxxxxL4
Ultrium 4 WORM Cartridge	xxxxxxLU
Ultrium 3 Data Cartridge	xxxxxxL3
Ultrium 3 WORM Cartridge	xxxxxxLT
Ultrium 2 Data Cartridge	xxxxxxL2
Ultrium 1 Data Cartridge (READ ONLY)	xxxxxxL1
LTO Ultrium Cleaning Cartridge	CLNxxxLx
*An Ultrium 3 Tape Drive must have a minimum firmware level of 54xx for it to be compatible with the WORM cartridge.	

To determine the complete specifications of the bar code and the bar code label, visit the web at http://www.ibm.com/ and enter "IBM LTO Ultrium Cartridge Label Specification" in the search box. Or contact your IBM sales representative.

When a bar code label is attached to a tape cartridge, place the label only in the recessed label area (see 5 in “LTO media” on page 55). A label that extends outside of the recessed area can cause loading problems in the drive.

Attention: Do not place any type of mark on the white space at either end of the bar code. A mark in this area might prevent the library from reading the label.

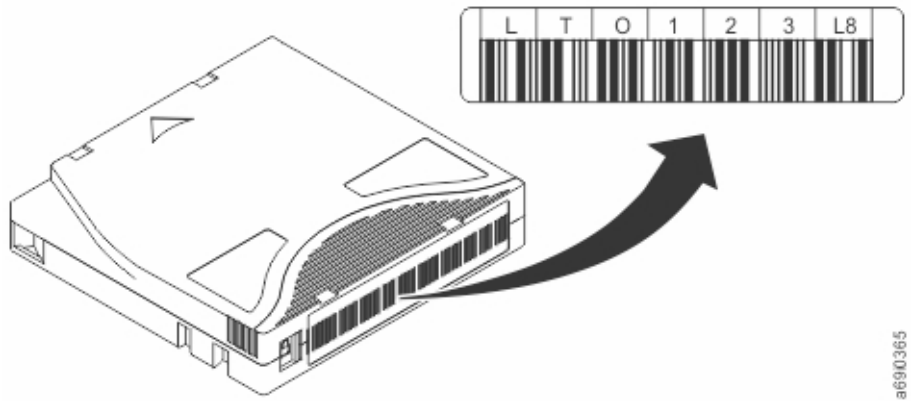

Figure 28. Sample bar code label on the LTO Ultrium Tape Cartridge

Inserting a tape cartridge

Several steps for inserting a tape cartridge.

About this task

To insert a tape cartridge:

Procedure

1. Ensure that the drive is powered-on.
2. Ensure that the write-protect switch on the tape cartridge is properly set (see "Write-Protect switch" on page 63).
3. Grasp the cartridge so that the write-protect switch faces you (see 1 in Figure 29 on page 92).
4. Slide the cartridge into the tape load compartment.

   Notes:

   a. If the cartridge is already in an ejected position and you want to reinsert it, remove the cartridge, then insert it again.

   b. If the cartridge is already loaded and you cycle the power (turn it off, then on), the tape reloads.

   c. Do not attempt to load a cartridge when the drive is in Maintenance mode until the drive requests it.

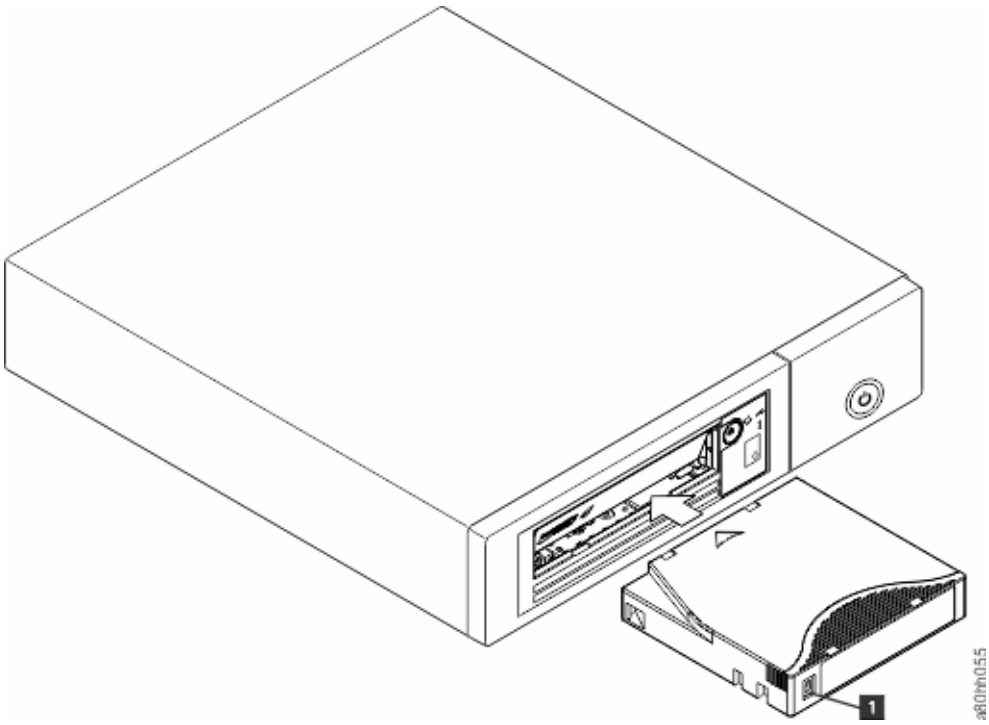

Figure 29. Inserting a cartridge into the drive

Single-character display (SCD)

The single-character display (SCD) is found on the front panel of the tape drive. The codes that are displayed provide information about drive status.

The SCD (5 in "Front right panel of the drive" on page 7) presents a single-character code for:

- Error conditions and informational messages
- Diagnostic or maintenance functions (while in maintenance mode only)

"Drive error codes and messages" on page 41 lists the codes for error conditions and informational messages. If multiple errors occur, the code with the highest priority (represented by the lowest number) displays first. When the error is corrected, the code with the next highest priority displays until no errors remain.

"Maintenance functions" on page 17 lists the single-character codes that represent diagnostic or maintenance functions. To initiate a function, the unit must be in maintenance mode.

The SCD is blank during normal operation.

SCD dot

If a drive memory dump is present while the drive is in maintenance mode, a single dot illuminates in the lower right corner of the SCD (see 6 in "Front right panel of the drive" on page 7). To copy the memory dump, see "Function code 5: Copy drive dump" on page 22.

The SCD dot is on solid if the memory dump is in RAM memory. The SCD dot flashes if the memory dump is in flash memory.

The SCD dot turns off when you obtain a dump (by using ITDT or a SCSI command) or update the drive firmware.

Note: If the drive memory dump is stored in RAM memory (SCD dot on solid), the memory dump is lost when you turn OFF the power or reset the drive.

Bar code label

Data cartridges can have bar code labels for identification..

A bar code label contains:

- A volume serial number (VOLSER) that is human-readable.
- A bar code that the library can read.

Note: LTO tape drives do not require tape cartridges to have bar code labels. However, IBM libraries require tape cartridges to have bar code labeled on them for automation and human readability.

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3582	Required
3583	Required
3584	Required

When read by a library's bar code reader, the bar code identifies the cartridge's VOLSER to the library. The bar code also tells the library whether the cartridge is a data cartridge or cleaning cartridge. In addition, the bar code includes the two-character media-type identifier, see Table 33 on page 94.

Figure 30 on page 95 shows a sample bar code label for the LTO Ultrium Tape Cartridge.

Tape cartridges are ordered with the labels included or with custom labels. To order tape cartridges and bar code labels, see "Ordering media supplies" on page 73. The bar code for usage in IBM tape libraries must meet predefined specifications. They include (but are not limited to):

- Eight uppercase alphanumeric characters, where the last 2 characters refer to the cartridge generation and WORM capability. See Table 33 on page 94.
- Label and printing to be non-glossy.
- Nominal narrow line or space width of 0.423 mm (0.017 in.)
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- Minimum bar length of 11.1 mm (0.44 in.)

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Ultrium 6 Data Cartridge	xxxxxxL6
Ultrium 6 WORM Cartridge	xxxxxxLW
Ultrium 5 Data Cartridge	xxxxxxL5
Ultrium 5 WORM Cartridge	xxxxxxLV
Ultrium 4 Data Cartridge	xxxxxxL4
Ultrium 4 WORM Cartridge	xxxxxxLU
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Ultrium 2 Data Cartridge	xxxxxxL2
Ultrium 1 Data Cartridge (READ ONLY)	xxxxxxL1
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Attention: Do not place any type of mark on the white space at either end of the bar code. A mark in this area might prevent the library from reading the label.

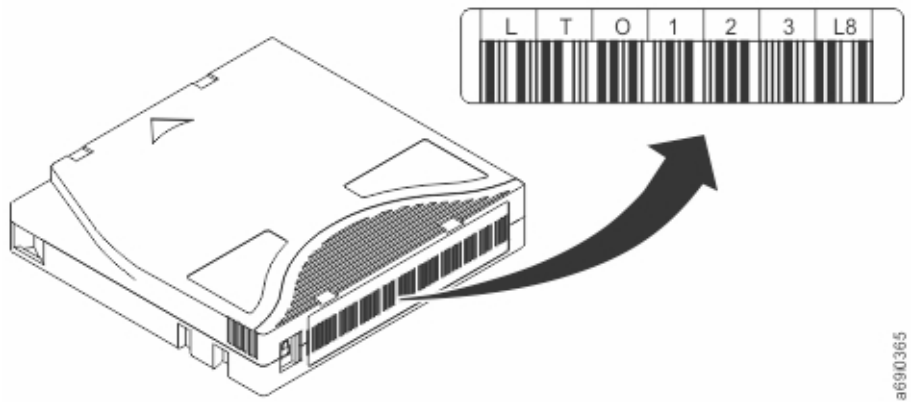

Figure 30. Sample bar code label on the LTO Ultrium Tape Cartridge

Publications

- *IBM Ultrium Tape Drive Quick Reference* (GC27-2278), illustrates how to install the drive.
- *IBM LTO Ultrium Tape Drive SCSI Reference* (GA32-0450), gives information about the supported SCSI commands and protocol that governs the behavior of the SCSI interface for LTO drives. The SCSI reference also includes information about the TapeAlert flags that are supported.
- IBM Tape Device Drivers and Diagnostic Tool User's Guide provides instructions for attaching IBM supported hardware to open-systems operating systems. It indicates what devices and levels of operating systems are supported. It also gives the requirements for adapters, and tells how to configure servers to use the device driver with the Ultrium family of devices. You can obtain this reference at: https://www-945.ibm.com/support/fixcentral
- IBM Tape Device Drivers Programming Reference supplies information to application developers who want to integrate their open-systems applications with IBM supported Ultrium hardware. The reference contains information about the application programming interfaces (APIs) for each of the various supported operating-system environments. You can obtain this reference at the website https://www-945.ibm.com/support/fixcentral.
- *IBM Safety Notices* (G229-9054), at https://www-01.ibm.com/support/docview.wss?uid=isg27d40fbeb5e10ceb985256e31007281fa.
- IBM Environmental Notices and User Guide (ENUG) (z125-5823), at https://www.ibm.com/support/knowledgecenter/ENVSAF_SHR/envsafetynotice/envsafetynotice_kickoff.htm. This information includes statements on limitations, product information, product recycling and disposal, battery information, flat panel display, refrigeration and water-cooling systems, external power supplies, and safety data sheets.
- IBM Security Key Lifecycle Manager Knowledge Center, at https://www.ibm.com/support/knowledgecenter/en/SSWPVP/sklm_welcome.html contains information to help you install, configure, and use the IBM Security Key Lifecycle Manager.
- The IBM Publications Center, at https://www-05.ibm.com/e-business/linkweb/publications/servlet/pbi.wss. The Publications Center is a worldwide central repository for IBM product publications and marketing material with a catalog of 70,000 items. Extensive search facilities are provided. Payment options for orders are with credit card (in the US) or customer number for 20 countries. Many publications are available online in various file formats, and they can all be downloaded by all countries, free of charge.

Glossary

This glossary defines the special terms, abbreviations, and acronyms that are used in this publication. If you do not find the term that you are looking for, refer to the index or to the *Dictionary of Computing,* 1994.

Numbers

2:1 compression
The relationship between the quantity of data that can be stored with compression as compared to the quantity of data that can be stored without compression. In 2:1 compression, twice as much data can be stored with compression as can be stored without compression.

A

A
Ampere.

ac
Alternating current.

access method
A technique for moving data between main storage and input or output devices.

adapter card
A circuit board that adds function to a computer.

adj
Adjustment.

AIX
Advanced Interactive Executive. IBM's implementation of the UNIX operating system. The RS/6000 system, among others, uses AIX as its operating system.

AL_PA
Arbitrated Loop Physical Address.

alphanumeric
Pertaining to a character set that contains letters, numerals, and other characters, such as punctuation marks.

alter
To change.

ambient temperature
The temperature of air or other media in a designated area, particularly the area that surrounds equipment.

ampere (A)
A unit of measure for electric current that is equivalent to a flow of one coulomb per second, or to the current produced by one volt applied across a resistance of one ohm.

ANSI
American National Standards Institute.

archive
To collect and store files in a designated place.

ASCII
American National Standard Code for Information Interchange. A 7 bit coded character set (8 bits including parity check) that consists of control characters and graphic characters.

assigning a device
The establishing of the relationship of a device to a running task, process, job, or program.

assignment
The naming of a specific device to complete a function.

asynchronous
Pertaining to two or more processes that do not depend upon the occurrence of specific events such as common timing signals.

attention (notice)
A word for calling attention to the possibility of danger to a program, device, or system, or to data. Contrast with *caution* and *danger*.

ATTN
Attention.

B

backup
To make extra copies of documents or software for safekeeping.

bar code
A code that represents characters by sets of parallel bars of varying thickness and separation that are read optically by transverse scanning.

bar code label
Paper bearing a bar code and having an adhesive backing. The bar code label must be affixed to a tape cartridge to enable the library to identify the cartridge and its volume serial number.

bar code reader
A laser device that is specialized for scanning and reading bar codes and converting them into either the ASCII or EBCDIC digital character code.

bezel
Decorative and safety cover.

bicolored
Having two colors.

bit
Either of the digits 0 or 1 when used in the binary numbering system.

BM or bill of materials
A list of specific types and amounts of direct materials that are expected to be used to produce a specific job or quantity of output.

browser
A client program that initiates requests to a Web server and displays the information that the server returns.

buffer
A routine or storage that is used to compensate for a difference in rate of flow of data or time of occurrence of events, when data is transferred from one device to another.

bus
A facility for transferring data between several devices that are located between two end points, only one device that is able to transmit at a specific moment.

byte
A string that consists of bits (usually 8) that are treated as a unit and represent a character. A fundamental data unit.

C

capacity
The amount of data that can be contained on storage media and expressed in bytes of data.

cartridge manual rewind tool
A device that can be fitted into the reel of a cartridge and used to rewind tape into or out of the cartridge.

cartridge storage slot
Individual slot that is located within a magazine that is used to house tape cartridges.

caution (notice)
A word to call attention to possible personal harm to people. Contrast with *attention* and *danger*.

CE
Customer engineer; field engineer; service representative.

centimeter (cm)
One one-hundredth of a meter (0.01 m). Approximately 0.39 inch.

channel command
An instruction that directs a data channel, control unit, or device to complete an operation or set of operations.

char
Character.

CHK
Check.

cleaning cartridge
A tape cartridge that is used to clean the heads of a tape drive. Contrast with *data cartridge*.

command
A control signal that initiates an action or the start of a sequence of actions.

compact disc (CD)
A disc, usually 4.75 inches in diameter, from which data is read optically by using a laser.

compression
The process of eliminating gaps, empty fields, redundancies, and unnecessary data to shorten the length of records or blocks.

concurrent
Refers to diagnostic procedures that can be run on one control unit while the rest of the subsystem remains available for customer applications.

contingent connection
A connection between a channel path and a drive that is caused when a unit check occurs during an I/O operation.

controller
A device that provides the interface between a system and one or more tape drives.

CP
Circuit protector.

ctrl
Control.

CU
Control unit.

D

danger (notice)
A word to call attention to possible lethal harm to people. Contrast with *attention* and *caution*.

data
Any representations such as characters or analog quantities to which meaning is or might be assigned.

data buffer
The storage buffer in the control unit. This buffer is used to increase the data transfer rate between the control unit and the channel.

data cartridge
A tape cartridge that is dedicated to storing data. Contrast with *cleaning cartridge*.

data check
A synchronous or asynchronous indication of a condition that is caused by invalid data or incorrect positioning of data.

dc
Direct current.

degauss
To make a magnetic tape nonmagnetic by using electrical coils that carry currents that neutralize the magnetism of the tape.

degausser
A device that makes magnetic tape nonmagnetic.

degradation
A decrease in quality of output or throughput or an increase in machine error rate.

degraded
Decreased in quality of output or throughput or increased machine error rate.

deserialize
To change from serial-by-bit to parallel-by-byte.

detented
A part that is held in position with a catch or lever.

device
Any hardware component or peripheral device, such as a tape drive or tape library, that can receive and send data.

device driver
A file that contains the code that is needed to use an attached device.

DIAG
Diagnostic section of maintenance information manual.

differential
See *High Voltage Differential (HVD)*.

direct access storage
A storage device in which the access time is independent of the location of the data.

DNS
Directory Name System. This system allows the library to recognize text-based addresses instead of numeric IP addresses.

download
To transfer programs or data from a computer to a connected device, typically a personal computer.

To transfer data from a computer to a connected device, such as a workstation or microcomputer.

DRAM
Dynamic random-access memory.

drive, magnetic tape
A mechanism for moving magnetic tape and controlling its movement.

DRV
Drive.

DSE
Data security erase.

DSP
Digital signal processor.

E

EBCDIC
Extended binary-coded decimal interchange code.

EC
Edge connector. Engineering change.

ECC
Error correction code.

EEPROM
Electrically erasable programmable read-only memory.

EIA
Electronics Industries Association.

EIA unit
A unit of measure, which is established by the Electronic Industries Association, equal to 44.45 millimeters (1.75 inches).

eject
To remove or force out from within.

electronic mail
Correspondence in the form of messages that are transmitted between user terminals over a computer network.

email
See *electronic mail*.

EPO
Emergency power off.

EPROM
Erasable programmable read only memory.

EQC
Equipment check.

equipment check
An asynchronous indication of a malfunction.

Error log
A data set or file in a product or system where error information is stored for later access.

ESD
Electrostatic discharge.

F

fault symptom code (FSC)
A hexadecimal code that is generated by the drive or the control unit microcode in response to a detected subsystem error.

FC
Feature code, or Fibre Channel.

FCC
Federal communications commission.

FE
Field engineer, customer engineer, or service representative.

Fibre Channel
A high-speed networking technology primarily used for transmitting data among data centers, computer servers, switches and storage at data rates of up to 128 Gbps. Fibre Channel is primarily used to connect computer data storage to servers in storage area networks (SAN) in commercial data centers.

fiducial
A target that is used for teaching a physical location to a robot.

field replaceable unit (FRU)
An assembly that is replaced in its entirety when any one of its components fails.

file
A named set of records that are stored or processed as a unit. Also referred to as a dataset.

file protection
The processes and procedures that are established in an information system that are designed to inhibit unauthorized access to, contamination of, or deletion of a file.

file transfer protocol (FTP)
In the Internet suite of protocols, an application layer protocol that uses TCP and Telnet services to transfer bulk-data files between machines or hosts.

firmware
Proprietary code that is delivered as microcode as part of an operating system. Firmware is more efficient than software loaded from an alterable medium and more adaptable to change than pure hardware circuitry. An example of firmware is the Basic Input/Output System (BIOS) in read-only memory (ROM) on a PC motherboard.

FLASH EEPROM
An electrically erasable programmable read-only memory (EEPROM) that can be updated.

FMR
Field microcode replacement.

format
The arrangement or layout of data on a data medium.

formatter
Part of a magnetic tape subsystem that completes data conversion, speed matching, encoding, first-level error recovery, and interfaces to one or more tape drives.

FP
File protect.

frayed
Damaged as if by an abrasive substance.

FRU
Field replaceable unit.

FSC
Fault symptom code.

FSI
Fault symptom index.

functional microcode
Microcode that is resident in the machine during normal customer operation.

G

g
Gram.

GB
gigabyte.

GBIC
Gigabit Interface Converter.

Gbi
gigabit

Generation 1
The informal name for the IBM Ultrium 1 Tape Drive, which is the first generation of the Ultrium tape drive. The Generation 1 drive has a native storage capacity of up to 100 GB per cartridge and a native sustained data transfer rate of 15 MB per second.

Generation 2
The informal name for the second-generation version of the IBM Ultrium Tape Drive. The Generation 2 drive has a native storage capacity of up to 200 GB per cartridge and a native sustained data transfer rate of 35 MB per second.

Generation 3
The informal name for the third-generation version of the IBM Ultrium Tape Drive. The Generation 3 drive has a native storage capacity of up to 400 GB per cartridge and a native sustained data transfer rate of 135 MB per second.

Generation 4
The informal name for the fourth-generation version of the IBM Ultrium Tape Drive. The Generation 4 drive has a native storage capacity of up to 800 GB per cartridge and a native sustained data transfer rate of 135 MB per second.

Generation 5
The informal name for the fifth-generation version of the IBM Ultrium Tape Drive. The Generation 5 drive has a native storage capacity of up to 1500 GB per cartridge and a native sustained data transfer rate of 140 MB per second.

Generation 6
The informal name for the sixth-generation version of the IBM Ultrium Tape Drive. The Generation 6 drive has a native storage capacity of up to 2500 GB per cartridge and a native sustained data transfer rate of 160 MB per second.

Generation 7
The informal name for the seventh-generation version of the IBM Ultrium Tape Drive. The Generation 7 drive has a native storage capacity of up to 6000 GB per cartridge and a native sustained data transfer rate of 300 MB per second.

Generation 8
The informal name for the eighth-generation version of the IBM Ultrium Tape Drive. The Generation 8 drive has a native storage capacity of up to 12 TB per cartridge and a native sustained data transfer rate of 300 MB per second.

Generation 9
The informal name for the ninth-generation version of the IBM Ultrium Tape Drive. The Generation 9 drive has a native storage capacity of up to 18 TB per cartridge and a native sustained data transfer rate of 300 MB per second.

gigabit (Gbit)
1 000 000 000 bits.

gigabyte (GB)
1 000 000 000 bytes.

Gigabit Interface Converter (GBIC)
Converts copper interface to optic interface.

gnd
Ground.

H

hertz (Hz)
Unit of frequency. One hertz equals one cycle per second.

hex
Hexadecimal.

High Voltage Differential (HVD)
A logic-signaling system that enables data communication between a supported host and the library. HVD signaling uses a paired plus and minus signal level to reduce the effects of noise on the SCSI bus. Any noise that is injected into the signal is present in both a plus and minus state, and is canceled. Synonymous with *differential*.

HVD
SCSI Bus High Voltage Differential

Hz
Hertz (cycles per second).

I

IBM Spectrum Archive
Formerly known as Linear Tape File System (LTFS). A file system that works with LTO Generation tape technology to access data stored on an IBM tape cartridge.

IBM Ultrium Tape Drive
Located within the library, a data-storage device that controls the movement of the magnetic tape in an IBM LTO Ultrium Tape Cartridge. The drive houses the mechanism (drive head) that reads and writes data to the tape.

ID
Identifier.

identifier (ID)
(1) In programming languages, a lexical unit that names a language object; for example, the names of variables, arrays, records, labels, or procedures. An identifier usually consists of a letter optionally followed by letters, digits, or other characters. (2) One or more characters that are used to identify or name data element and possibly to indicate certain properties of that data element. (3) A sequence of bits or characters that identifies a program, device, or system to another program, device, or system.

IML
Initial microprogram load.

initial microprogram load (IML)
The action of loading a microprogram from an external storage to writable control storage.

initiator
The component that runs a command. The initiator can be the host system or the tape control unit.

INST
Installation.

interface
A shared boundary. An interface might be a hardware component to link two devices or it might be a portion of storage or registers accessed by two or more computer programs.

interposer
The part that is used to convert a 68-pin connector to a 50-pin D-shell connector.

intervention required
Manual action is needed.

INTRO
Introduction.

I/O
Input/output.

IOP
Input/output processor.

IPL
Initial program load.

ITST
Idle-time self-test.

K

kilogram (kg)
One thousand grams (approximately 2.2 pounds).

km
kilometer. 1000 Meters, Approximately 5/8 mile.

L

LAN
Local area network. A computer network within a limited area.

LCD
See *liquid crystal display*.

LDAP
Lightweight Directory Access Protocol. This protocol allows the library to use login and password information that is stored on a server to grant access to the library functionality.

LED
Light-emitting diode.

LID
Loop ID.

Linear Tape File System (LTFS)
See *IBM Spectrum Archive*.

Linear Tape-Open (LTO)
A type of tape storage technology that is developed by the IBM Corporation, Hewlett-Packard, and Certance. LTO technology is an “open format” technology, which means that its users have multiple sources of product and media. The “open” nature of LTO technology enables compatibility between different vendors' offerings by ensuring that vendors comply with verification standards. The LTO technology is implemented in two formats: the Accelis format focuses on fast access; the Ultrium format focuses on high capacity. The Ultrium format is the preferred format when capacity (rather than fast access) is the key storage consideration. An Ultrium cartridge has a compressed data capacity of up to 800 GB (2:1 compression) and a native data capacity of up to 400 GB.

liquid crystal display (LCD)
A low-power display technology that is used in computers and other I/O devices.

loadable
Having the ability to be loaded.

LTO cartridge memory (LTO-CM)
Within each LTO Ultrium data cartridge, an embedded electronics and interface module that can store and retrieve a cartridge's historical usage and other information.

LVD
SCSI Bus Low Voltage Differential

M

m
Meter. In the Metric System, the basic unit of length; equal to approximately 39.37 inches.

M8
LTO Type M Data Cartridge.

MB
Mega Byte (expressed as data rate in MB/s or MB/second).

magnetic tape
A tape with a magnetic surface layer on which data can be stored by magnetic recording.

MAP
Maintenance analysis procedure.

mask
A pattern of characters that controls the retention or elimination of portions of another pattern of characters. To use a pattern of characters to control the retention or elimination of portions of another pattern of characters.

master file
A file that is used as an authority in a specific job and that is relatively permanent, even though its contents might change. Synonymous with main file.

media capacity
The amount of data that can be contained on a storage medium, expressed in bytes of data.

media-type identifier
Pertaining to the bar code on the bar code label of the IBM Ultrium Tape Cartridge, a 2-character code, L1, that represents information about the cartridge. L identifies the cartridge as one that can be read by devices that incorporate LTO technology; 1 indicates that it is the first generation of its type.

mega
One million of.

meter
In the Metric System, the basic unit of length; equal to approximately 39.37 inches.

micro
One millionth of.

microcode
(1) One or more micro instructions. (2) A code, representing the instructions of an instruction set, which is implemented in a part of storage that is not program-addressable. (3) To design, write, and test one or more micro instructions. (4) See also *microprogram*.

microdiagnostic routine
A program that runs under the control of a supervisor, usually to identify field replaceable units.

microdiagnostic utility
A program that is run by the customer engineer to test the machine.

microinstruction
A basic or elementary machine instruction.

microprogram
A group of microinstructions that when run completes a planned function.

The term microprogram represents a dynamic arrangement or selection of one or more groups of microinstructions for execution to run a particular function. The term microcode represents microinstructions that are used in a product as an alternative to hard-wired circuitry to implement certain functions of a processor or other system component.

MIM
Media information message.

mm
Millimeter.

modifier
That which changes the meaning.

mount a device
To assign an I/O device with a request to the operator.

MP
Microprocessor.

ms
Millisecond.

MSG
Message.

multipath
Pertaining to using more than one path.

N

N/A
Not applicable.

node
In a network, a point at which one or more functional units connect channels or data circuits.

NTP
Network Time Protocol. This protocol allows the library to set its internal date and time that is based on the date and time of a sever.

NVS
Nonvolatile storage. A storage device whose contents are not lost when power is cut off.

O

oersted
The unit of magnetic field strength in the unrationalized centimeter-gram-second (cgs) electromagnetic system. The oersted is the magnetic field strength in the interior of an elongated, uniformly wound solenoid that is excited with a linear current density in its winding of one abampere per 4π centimeters of axial length.

offline
Pertaining to the operation of a functional unit without the continual control of a computer. Contrast with *online*.

online
Pertaining to the operation of a functional unit that is under the continual control of a computer. Contrast with *offline*.

OPER
Operation.

ov
Over voltage.

overrun
Loss of data because a receiving device is unable to accept data at the rate it is transmitted.

overtightening
To tighten too much.

P

parameter
A variable that is given a constant value for a specified application and that can denote the application.

p bit
Parity bit.

PC
Parity check.

PCC
Power control compartment.

PDF
Portable Document Format.

PE
Parity error. Product engineer.

pick
Pertaining to the library, to remove, by using a robotic device, a tape cartridge from a storage slot or drive.

picker
A robotic mechanism that is located inside the library that moves cartridges between the cartridge storage slots and the drive.

PM
Preventive maintenance.

POR
Power-on reset.

port
A physical connection for communication between the 3590 and the host processor. The 3590 has two SCSI ports.

Portable Document Format (PDF)
A standard that is specified by Adobe Systems, Incorporated, for the electronic distribution of documents. PDF files are compact, can be distributed globally (email, the Web, intranets, or CD-ROM), and can be viewed with the Acrobat Reader. The Acrobat Reader is software from Adobe Systems that can be downloaded at no cost from the Adobe Systems home page.

PROM
Programmable read only memory.

PS
Power supply.

PWR
Power.

R

rack
A unit that houses the components of a storage subsystem, such as the library.

rackmount kit
A packaged collection of articles that are used to install the rack-mounted version of the library.

RAM
Random access memory.

Random access memory
A storage device into which data is entered and from which data is retrieved in a nonsequential manner.

RAS
Reliability, availability, and serviceability.

record
A collection of related data or words, which are treated as a unit.

recording density
The number of bits in a single linear track measured per unit of length of the recording medium.

recoverable error
An error condition that allows continued execution of a program.

ref
Reference.

reg
Register.

reinventory
To inventory again.

retension
The process or function of tightening the tape onto the cartridge, if it is sensed that the tape has a loose wrap on the cartridge.

robot
Picker.

robotics
Picker assembly.

RPQ
Request for price quotation.

R/W
Read/write.

S

s
Seconds of time.

SAC
Service Action Code. Code that is developed to indicate possible FRU or FRUs to replace to repair the hardware.

SAS
Serial Attached SCSI interface.

scratch cartridge
A data cartridge that contains no useful data, but can be written to with new data.

SCSI
Small computer system interface.

segment
A part.

sel
Select.

serialize
To change from parallel-by-byte to serial-by-bit.

serializer
A device that converts a space distribution of simultaneous states that represents data into a corresponding time sequence of states.

servo, servos
An adjective for use in qualifying some part or aspect of a servomechanism.

servomechanism
A feedback control system in which at least one of the system signals represents mechanical motion.

Small Computer Systems Interface (SCSI)
A standard that is used by computer manufacturers for attaching peripheral devices (such as tape drives, hard disks, CD-ROM players, printers, and scanners) to computers (servers). Pronounced “scuzzy”. Variations of the SCSI interface provide for faster data transmission rates than standard serial and parallel ports (up to 160 megabytes per second). The variations include

- Fast/Wide SCSI: Uses a 16-bit bus, and supports data rates of up to 20 MBps.
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- Ultra3 SCSI: Uses a 16-bit bus and supports data rates of 80 or 160 MBps.
- Ultra160 SCSI: Uses a 16-bit bus and supports data rates of 80 or 160 MBps.

SNS
Sense.

special feature
A feature that can be ordered to enhance the capability, storage capacity, or performance of a product, but is not essential for its basic work.

SR
Service representative, see also *CE*.

SRAM
Static Random Access Memory.

SS
Status store.

ST
Store.

standard feature
The significant design elements of a product that are included as part of the fundamental product.

START
Start maintenance.

subsystem
A secondary or subordinate system, capable of operating independently of, or asynchronously with, a controlling system.

SUPP
Support.

sync
Synchronous, synchronize. Occurring with a regular or predictable time relationship.

T

tachometer, tach
A device that emits pulses that are used to measure/check speed or distance.

tape cartridge
A container-holding magnetic tape that can be processed without separating it from the container.

tape void
An area in the tape in which no signal can be detected.

TB
terabyte

TCP/IP
Transmission Control Protocol/Internet Protocol.

TCU
Tape control unit.

Terabyte
One terabyte (TB) = 1,000,000,000,000 bytes, or 1000 gigabytes (GBs).

TH
Thermal.

thread/load operation
A procedure that places tape along the tape path.

TM
Tapemark.

U

UART
Universal asynchronous receiver/transmitter.

Universal Serial Bus (USB)
An interface standard that manufacturers use to connect peripheral devices (such as tape drives, hard disk drives, and printers) to computers (host servers). Variations of the USB interface have different data transmission rates. The variations include USB 1.1, USB 2.0, USB 3.0.

unload
Prepare the tape cartridge for removal from the drive.

utilities
Utility programs.

utility programs
A computer program in general support of the processes of a computer; for instance, a diagnostic program.

uv
Under voltage.

V

VOLSER
Volume serial number.

volume
A certain portion of data, together with its data carrier, that can be handled conveniently as a unit.

VPD
Vital product data. The information that is contained within the tape drive that requires nonvolatile storage that is used by functional areas of the drive, and information that is required for manufacturing, RAS, and engineering.

W

word
A character string that is convenient for some purpose to consider as an entity.

Write
Write command.

WT
world trade.

X

XR
External register.

XRA
External register address register.

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В жилых помещениях оно может создавать
радиопомехи, для снижения которых необходимы
дополнительные меры

rusemi

Taiwan Notice

警告使用者：
此為甲類資訊技術設備，
於居住環境中使用時，
可能會造成射頻擾動，在此種情況下，
使用者會被要求採取某些適當的對策。

IBM Taiwan Contact Information:

United Kingdom Notice

This product may cause interference if used in residential areas. Such use must be avoided unless the user takes special measures to reduce electromagnetic emissions to prevent interference to the reception of radio and television broadcasts.

United States Federal Communications Commission (FCC) Notice

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

Properly shielded and grounded cables and connectors must be used in order to meet FCC emission limits. IBM is not responsible for any radio or television interference caused by using other than recommended cables and connectors, or by unauthorized changes or modifications to this equipment. Unauthorized changes or modifications could void the user's authority to operate the equipment.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device might not cause harmful interference, and (2) this device must accept any interference received, including interference that might cause undesired operation.

Responsible Party:

International Business Machines Corporation
New Orchard Road
Armonk, NY 10504
Contact for FCC compliance information only: fccinfo@us.ibm.com

Safety and environmental notices

When this product is used, observe the danger, caution, and attention notices that are contained in this guide. The notices are accompanied by symbols that represent the severity of the safety condition.

Most danger or caution notices contain a reference number (Dxxxx or Cxxxx). Use the reference number to check the translation in the *IBM Systems Safety Information* (G229-9054) publication included in your ship group.

The sections that follow define each type of safety notice and give examples.

Attention notices

Danger notices

A danger notice calls attention to a situation that is potentially lethal or extremely hazardous to people. A lightning bolt symbol always accompanies a danger notice to represent a dangerous electrical condition.

To prevent a possible shock from touching two surfaces with different protective ground(earth), use one hand, when possible, to connect or disconnect signal cables. (D001)

Overloading a branch circuit is potentially a fire hazard and a shock hazard under certain conditions. To avoid these hazards, ensure that your system electrical requirements do not exceed branch circuit protection requirements. Refer to the information that is provided with your device or the power rating label for electrical specifications. (D002)

If the receptacle has a metal shell, do not touch the shell until you have completed the voltage and grounding checks. Improper wiring or grounding could place dangerous voltage on themetal shell. If any of the conditions are not as described, STOP. Ensure the improper voltage or impedance conditions are corrected before proceeding.(D003)

An electrical outlet that is not correctly wired could place hazardous voltage on the metal parts of the system or the devices that attach to the system. It is the responsibility of the customer to ensure that the outlet is correctly wired and grounded to prevent an electrical shock.(D004)

When working on or around the system, observe the following precautions:

Electrical voltage and current from power, telephone, and communication cables are hazardous. To avoid a shock hazard:

- If IBM supplied a power cord(s), connect power to this unit only with the IBM provided power cord. Do not use the IBM provided power cord for any other product.
- Do not open or service any power supply assembly.
- Do not connect or disconnect any cables or perform installation, maintenance, or reconfiguration of this product during an electrical storm.
- The product might be equipped with multiple power cords. To remove all hazardous voltages, disconnect all power cords.
  - For AC power, disconnect all power cords from their AC power source.
  - For racks with a DC power distribution panel (PDP), disconnect the customer’s DC powersource to the PDP.
- When connecting power to the product ensure all power cables are properly connected.
  - For racks with AC power, connect all power cords to a properly wired and grounded electrical outlet. Ensure that the outlet supplies proper voltage and phase rotation according to the system rating plate.
  - For racks with a DC power distribution panel (PDP), connect the customer’s DC power source to the PDP. Ensure that the proper polarity is used when attaching the DC power and DC power return wiring.
- Connect any equipment that will be attached to this product to properly wired outlets.

- When possible, use one hand only to connect or disconnect signal cables.
- Never turn on any equipment when there is evidence of fire, water, or structural damage.
- Do not attempt to switch on power to the machine until all possible unsafe conditions are corrected.
- Assume that an electrical safety hazard is present. Perform all continuity, grounding, and power checks specified during the subsystem installation procedures to ensure that the machine meets safety requirements.
- Do not continue with the inspection if any unsafe conditions are present.

- Before you open the device covers, unless instructed otherwise in the installation and configuration procedures: Disconnect the attached AC power cords, turn off the applicable circuit breakers located in the rack power distribution panel (PDP), and disconnect any telecommunications systems, networks, and modems.
- Connect and disconnect cables as described in the following procedures when installing, moving, or opening covers on this product or attached devices.

To disconnect:

1. Turn off everything (unless instructed otherwise).
2. For AC power, remove the power cords from the outlets.
3. For racks with a DC power distribution panel (PDP), turn off the circuit breakers located in the PDP and remove the power from the Customer's DC power source.
4. Remove the signal cables from the connectors.
5. Remove all cables from the devices.

To connect:

1. Turn off everything (unless instructed otherwise).
2. Attach all cables to the devices.
3. Attach the signal cables to the connectors.
4. For AC power, attach the power cords to the outlets.
5. For racks with a DC power distribution panel (PDP), restore the power from the Customer'sDC power source and turn on the circuit breakers located in the PDP.
6. Turn on the devices.

- Sharp edges, corners and joints may be present in and around the system. Use care when handling equipment to avoid cuts, scrapes and pinching. (D005)

Heavy equipment - personal injury or equipment damage might result if mishandled. (D006)

<table>
<tr>
<td rowspan="4">  </td>
<td>Uninterruptible power supply (UPS) units contain specific hazardous materials. Observe the following precautions if your product contains a UPS:
• The UPS contains lethal voltages. All repairs and service must be performed only by an authorized service support representative. There are no user serviceable parts inside the UPS.
• The UPS contains its own energy source (batteries). The output receptacles might carry live voltage even when the UPS is not connected to an AC supply.
• Do not remove or unplug the input cord when the UPS is turned on. This removes the safety ground from the UPS and the equipment connected to the UPS.
• The UPS is heavy because of the electronics and batteries that are required. To avoid injury,observe the following precautions:
– Do not attempt to lift the UPS by yourself. Ask another service representative for assistance.
– Remove the battery, electronics assembly, or both from the UPS before removing the UPS from the shipping carton or installing or removing the UPS in the rack.
(D007)</td>
</tr>
<tr>
<td>Professional movers are to be used for all relocation activities. Serious injury or death might occur if systems are handled and moved incorrectly. (D008)</td>
</tr>
<tr>
<td>Ensure that your DC mains supply is earthed at the point of generation per IEC 60950-1and ITU-T Recommendation K.27. (D009)</td>
</tr>
<tr>
<td>Serious injury or death can occur if loaded lift tool falls over or if a heavy load falls off the lift tool. Always completely lower the lift tool load plate and properly secure the load on the lift tool before moving or using the lift tool to lift or move an object. (D010)</td>
</tr>
<tr>
<td>  </td>
<td>  DANGER: Multiple power cords. The product might be equipped with multiple AC power cords or multiple DC power cables. To remove all hazardous voltages, disconnect all power cords and power cables. (L003)</td>
</tr>
</table>

Caution notices

A caution notice calls attention to a situation that is potentially hazardous to people because of some existing condition, or to a potentially dangerous situation that might develop because of some unsafe practice.

<table>
<tr>
<td rowspan="3">  </td>
<td>The doors and covers to the product are to be closed at all times except for service by trained service personnel. All covers must be replaced and doors closed at the conclusion of the service operation. (C013)</td>
</tr>
<tr>
<td>This product is equipped with a 3-wire (two conductors and ground) power cable and plug. Use this power cable with a properly grounded electrical outlet to avoid electrical shock. (C018)</td>
</tr>
<tr>
<td>This assembly contains mechanical moving parts. Use care when servicing this assembly. (C025)</td>
</tr>
</table>

A caution notice can be accompanied by one of several symbols:

If the symbol is...	It means...
	A generally hazardous condition not represented by other safety symbols.
	A hazardous condition due to the use of a laser in the product. Laser symbols are always accompanied by the classification of the laser as defined by the U. S. Department of Health and Human Services (for example, Class I, Class II, and so forth).
	Risk of hand pinching, can trap hands, fingers and cause serious injury. Keep hands clear during operation (L012).
	A hazardous condition due to the weight of the unit. Weight symbols are accompanied by an approximation of the product's weight.
	A hazardous condition due to the unit's susceptibility to electrostatic discharge.

Possible safety hazards

Possible safety hazards to the operation of this product are:

Electrical
An electrically charged frame can cause serious electrical shock.

Mechanical
Hazards (for example, a safety cover missing) are potentially harmful to people.

Chemical
Do not use solvents, cleaners, or other chemicals that are not approved for use on this product.

Before the library is used, repair any of the preceding problems.

Class I laser product

Before the library is used, review the following laser safety information.

The product might contain a laser assembly that complies with the performance standards set by the US Food and Drug Administration for a Class I laser product. Class I laser products do not emit hazardous laser radiation. The product has the necessary protective housing and scanning safeguards to ensure that laser radiation is inaccessible during operation or is within Class I limits. External safety agencies reviewed the product and obtained approvals to the latest standards as they apply.

Acclimation

Tape storage equipment must be gradually acclimated to the surrounding environment to prevent condensation.

When storage equipment is shipped in a climate where the outside temperature is below the dew point of the destination (indoor location), water condensation can form on the cooler inside and outside surfaces of the equipment when the equipment is brought indoors.

Sufficient time must be allowed for the shipped equipment to gradually reach thermal equilibrium with the indoor environment before you remove the shipping bag and energize the equipment. Follow these guidelines to properly acclimate your equipment:

- Leave the system in the shipping bag. If the installation or staging environment allows it, leave the product in the full package to minimize condensation on or within the equipment.
- Allow the packaged product to acclimate for 24 hours[1]. If visible signs of condensation (either external or internal to the product) are seen after 24 hours, acclimate the system without the shipping bag for an extra 12 - 24 hours or until no visible condensation remains.
- Acclimate the product away from perforated tiles or other direct sources of forced air convection to minimize excessive condensation on or within the equipment.

[1] Unless otherwise stated by product-specific installation instructions.

Note: Condensation is a normal occurrence, especially when you ship equipment in cold-weather climates. All IBM products are tested and verified to withstand condensation that is produced under these circumstances. When sufficient time is provided to allow the hardware to gradually acclimate to the indoor environment, no issues with long-term reliability of the product should occur.

Performing the safety inspection procedure

Before you service the unit, complete the following safety inspection procedure.

1. Stop all activities between the host and the library’s tape drives.
2. Turn off the power to the library by pushing in the **Power** button on the front of the tape library for 4 seconds.
3. Unplug the library’s power cord from the electrical outlet and the library’s power supply unit.
4. Check the library’s power cords for damage, such as a pinched, cut, or frayed cord.
5. If drives are FC/SAS attached, check the tape drive's FC/SAS cable for damage.
6. Check the top and bottom covers of the library for sharp edges, damage, or alterations that expose its internal parts.
7. Check the top and bottom covers of the library for proper fit. They must be in place and secure.
8. Check the product label at the rear of the library to make sure that it matches the voltage at your outlet.

Rack safety

The following general safety information must be used for all rack-mounted devices.

DANGER

Observe the following precautions when working on or around your IT rack system.

- Heavy equipment - personal injury or equipment damage might result if mishandled.
- Always lower the leveling pads on the rack cabinet.
- Always install stabilizer brackets on the rack cabinet.
- To avoid hazardous conditions due to uneven mechanical loading, always install the heaviest devices in the bottom of the rack cabinet. Always install servers and optional devices starting from the bottom of the rack cabinet.
- Rack-mounted devices are not to be used as shelves or work spaces. Do not place objects on top of rack-mounted devices. In addition, do not lean on rack mounted devices and do not use them to stabilize your body position (for example, when working from a ladder).

- Each rack cabinet might have more than one power cord.
  - For AC powered racks, be sure to disconnect all power cords in the rack cabinet when directed to disconnect power during servicing.
  - For racks with a DC power distribution panel (PDP), turn off the circuit breaker that controls the power to the system unit(s), or disconnect the customer's DC power source, when directed to disconnect power during servicing.
- Connect all devices installed in a rack cabinet to power devices installed in the same rack cabinet. Do not plug a power cord from a device installed in one rack cabinet into a power device installed in a different rack cabinet.
- An electrical outlet that is not correctly wired could place hazardous voltage on the metal parts of the system or the devices that attach to the system. It is the responsibility of the customer to ensure that the outlet is correctly wired and grounded to prevent an electrical shock. (R001 part 1 of 2)

Caution

- Do not install a unit in a rack where the internal rack ambient temperatures might exceed the manufacturer's recommended ambient temperature for all your rack-mounted devices.
- Do not install a unit in a rack where the air flow is compromised. Ensure that air flow is not blocked or reduced on any side, front, or back of a unit that is used for air flow through the unit.
- Consideration must be given to the connection of the equipment to the supply circuit so that overloading of the circuits does not compromise the supply wiring or overcurrent protection. To provide the correct power connection to a rack, refer to the rating labels on the equipment in the rack to determine the total power requirement of the supply circuit.

- (For sliding drawers) Do not pull out or install any drawer or feature if the rack stabilizer brackets are not attached to the rack. Do not pull out more than one drawer at a time. The rack might become unstable if you pull out more than one drawer at a time.

- (For fixed drawers) This drawer is a fixed drawer and must not be moved for servicing unless specified by the manufacturer. Attempting to move the drawer partially or out of the rack might cause the rack to become unstable or cause the drawer to fall out of the rack. (R001 part 2 of 2)

Caution

Removing components from the upper positions in the rack cabinet improves rack stability during relocation. Follow these general guidelines whenever you relocate a populated rack cabinet within a room or building:

- Reduce the weight of the rack cabinet by removing equipment, starting at the top of the rack cabinet. When possible, restore the rack cabinet to the configuration of the rack cabinet as you received it. If this configuration is not known, you must do the following:
  - Remove all devices in the 32U position (compliance ID RACK-001) or 22U (compliance ID RR001) and above.
  - Ensure that the heaviest devices are installed in the bottom of the rack cabinet.
  - Ensure that there are little-to-no empty U-levels between devices installed in the rack-cabinet below the 32U (compliance ID RACK-001) or 22U (compliance ID RR001) level, unless the received configuration specifically allowed it.
- If the rack cabinet you are relocating is part of a suite of rack cabinets, detach the rack cabinet from the suite.
- If the rack cabinet you are relocating was supplied with removable outriggers, they must be reinstalled before the cabinet is relocated.
- Inspect the route that you plan to take to eliminate potential hazards.
- Verify that the route that you choose can support the weight of the loaded rack cabinet. Refer to the documentation that comes with your rack cabinet for the weight of a loaded rack cabinet.
- Verify that all door openings are at least 760 x 2032 mm (30 x 80 in.).
- Ensure that all devices, shelves, drawers, doors, and cables are secure.
- Ensure that the four leveling pads are raised to their highest position.
- Ensure that no stabilizer bracket is installed on the rack cabinet during movement.
- Do not use a ramp that is inclined at more than 10 degrees.
- When the rack cabinet is in the new location, complete these steps.
  - Lower the four leveling pads.
  - Install stabilizer brackets on the rack cabinet or in an earthquake environment bolt the rack to the floor.

  - If you removed any devices from the rack cabinet, repopulate the rack cabinet from the lowest position to the highest position.
- If a long-distance relocation is required, restore the rack cabinet to the configuration of the rack cabinet as you received it. Pack the rack cabinet in the original packaging material, or equivalent. Also, lower the leveling pads to raise the casters off the pallet and bolt the rack cabinet to the pallet. (R002)
-  **DANGER:** Racks with a total weight of > 227 kg (500 lb.), Use Only Professional Movers! (R003)

Caution

- Rack is not intended to serve as an enclosure and does not provide any degrees of protection required of enclosures.
- It is intended that equipment installed within this rack will have its own enclosure. (R005)
- Tighten the stabilizer brackets until they are flush against the rack. (R006)
- Use safe practices when lifting. (R007)
- Do not place any object on top of a rack-mounted device unless that rack-mounted device is intended for use as a shelf. (R008)
- If the rack is designed to be coupled to another rack only the same model rack should be coupled together with another same model rack. (R009)

Danger

Main Protective Earth (Ground): This symbol is marked on the frame of the rack. The PROTECTIVE EARTHING CONDUCTORS must be terminated at that point. A recognized or certified closed loop connector (ring terminal) must be used and secured to the frame with a lock washer using a boltor stud. The connector must be properly sized to be suitable for the bolt or stud, the locking washer, the rating for the conducting wire used, and the considered rating of the breaker. The intent is to ensure the frame is electrically bonded to the PROTECTIVE EARTHING CONDUCTORS. The hole that the bolt or stud goes into where the terminal connector and the lock washer contact must be free of any non-conductive material to allow for metal to metal contact. All PROTECTIVE BONDING CONDUCTORS must terminate at this main protective earthing terminal or at points marked with  . (R010)

Always ensure that a load of 95 kg (210 lb) is inside the bottom of the rack (compliance ID RR001), especially before relocating or servicing units with their Center of Gravity (CoG) higher than 22U. (R011)

Power cords

For your safety, IBM provides a power cord with a grounded attachment plug to use with this IBM product. To avoid electrical shock, always use the power cord and plug with a properly grounded outlet.

IBM power cords that are used in the United States and Canada are listed by Underwriter's Laboratories (UL) and certified by the Canadian Standards Association (CSA).

For units intended to be operated at 115 volts: Use a UL-listed and CSA-certified cord set consisting of a minimum 18 AWG, Type SVT or SJT, three-conductor cord, a maximum of 15 feet in length and a parallel blade, grounding-type attachment plug rated 15 amperes, 125 volts.

For units intended to be operated at 230 volts (US use): Use a UL-listed and CSA-certified cord set consisting of a minimum 18 AWG, Type SVT or SJT, three-conductor cord, a maximum of 15 feet in length and a tandem blade, grounding-type attachment plug rated 15 amperes, 250 volts.

For units intended to be operated at 230 volts (outside the US): Use a cord set with a grounding-type attachment plug. The cord set must have the appropriate safety approvals for the country in which the equipment is installed.

IBM power cords for a specific country or region are usually available only in that country or region.

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